JUL 8 1930

Heating · Piping and Air Conditioning

July, 1930

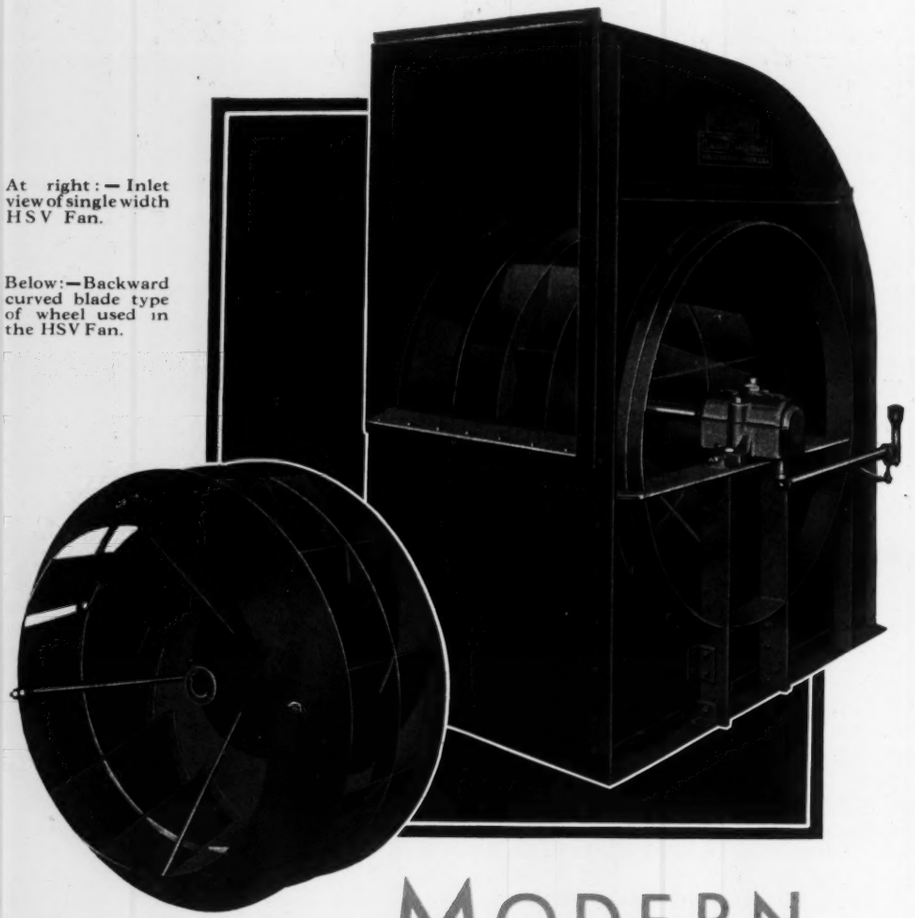
Articles on

Heating—
By J. C. PEEBLES *and* SAMUEL R. LEWIS

Piping—
By G. W. HAEUCK *and* BRYAN T. McMINN

Air Conditioning—
By A. N. CHANDLER *and* RUSH D. TOUTON

Journal Section of A. S. H. V. E.



At right:—Inlet view of single width HSV Fan.

Below:—Backward curved blade type of wheel used in the HSV Fan.

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Published Monthly by Engineering Publications, Inc. 1900 Prairie Avenue, Chicago

TERMS OF SUBSCRIPTION

Anywhere in the world, $3.00 per year.

Current copies, 50c each. Back numbers, $1.00 each.

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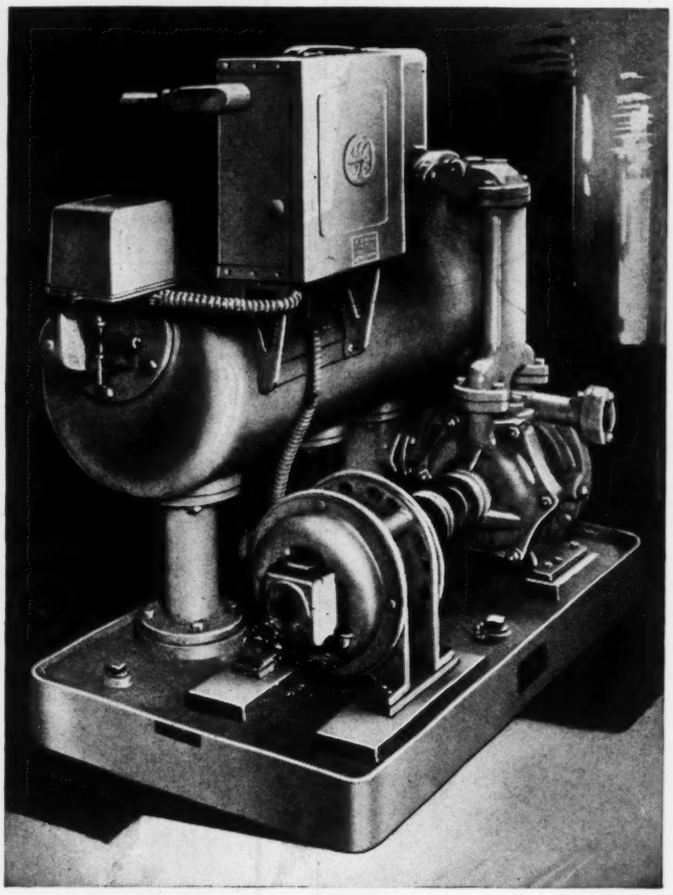

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Heating · Piping
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Vol. II July, 1930 No. 7

Controlled Weather Produces Quality Cigars

By Rush D. Touton*

FIG. 1—MAIN OFFICE AND PLANT OF BAYUK CIGARS, INC., AT PHILADELPHIA. OPEN WINDOWS ARE USED IN SEVENTH FLOOR OFFICES AND TENTH FLOOR SPRAY POND ONLY; ALL OTHERS REMAIN CLOSED. THIS PLANT EMPLOYS 1800 PEOPLE AND PRODUCES 800,000 CIGARS DAILY

RETURNING from their first visit to the American continent, the Spanish explorers described the Indians as "consuming large bundles of a native herb by setting fire to one extremity and drawing smoke through the other end into their mouths. This practice occasionally seems to take the place of food in times of stress or great deliberation." This was the predecessor of the cigar with which we are familiar.

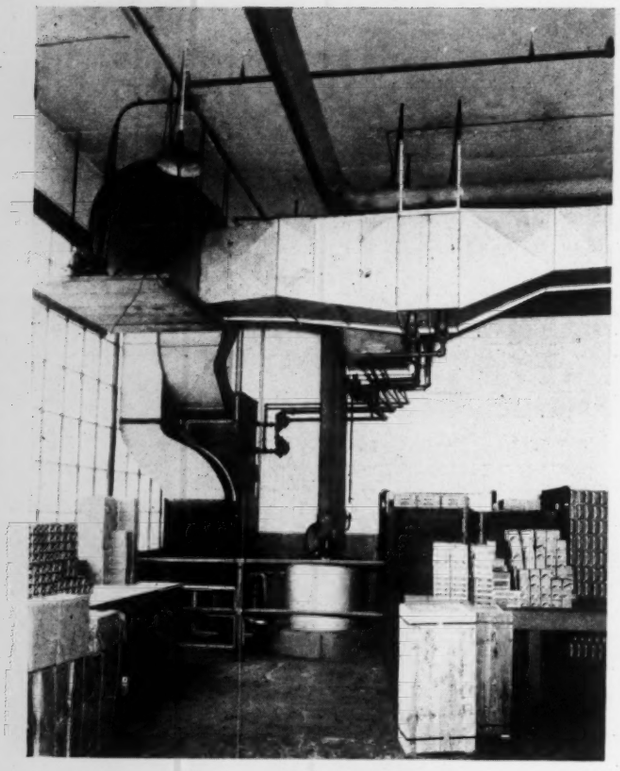
In a more detailed description given by one of the later explorers, the method used by these early Americans in curing tobacco was explained. Emphasis was laid on the practice of drying the green leaves near an open fire, but without permitting the leaves to receive enough heat to become brittle.

Atmospheric conditions are still the most important controllable factor in every phase of cigar production. The evolution of the thoroughly enjoyable modern cigar from the "large bundle of smoking herb" is closely aligned with the perfection of drying, curing and manufacturing methods provided by the science of air conditioning.

The Raw Material

The raw material, or the tobacco itself, has an extremely rapid growth and the characteristics of the leaf—its texture, aroma, size, color, burn, elasticity, etc.—are decidedly dependent upon the weather prevailing during the short life cycle of the plant. It is not at all uncommon to learn of the value of an entire crop being cut in half by by so little as five or six days of continued rainy or dry weather during the period of final development. This condition has confined the tobacco growing areas to relatively small districts in a very few favored climates. It is also of interest that the growers in some of these regions have extensive irrigation plants, which enable them in some measure to avoid the resultant heavy, bitter "dry weather" tobacco which comes from too little rainfall. As further evidence of the growers' efforts to temper climate, some eight thousand acres of cloth are spread over a certain section of the Con-

* Technical Director, Bayuk Cigars Inc.



necticut Valley to protect the tobacco plants from the damaging direct rays of the sun.

Regulation of air conditions becomes very important after harvesting the tobacco. The average moisture content of the leaf at this time is 80 per cent, a figure which must be reduced to approximately 25 per cent before the product is at all ready for use. This entails the removal of some sixteen thousand pounds of water for each ton of cured tobacco. The relatively simple problem of moisture removal is seriously complicated by the fact that the chemical reactions incident to the death of the leaf cells and the change of the green coloring matter into the familiar brown must proceed in perfect co-ordination with the actual drying. The green spots which are frequently prominent on the wrapper leaf of cigars are simply this green coloring matter fixed in the leaf by the breaking down of the cell structure because of too rapidly lowering the moisture content. This condition also gives the wrapper leaf a papery appearance. A dark, mottled wrapper, on the other hand, indicates a retarded drying and is equally detrimental.

Through long and costly experience, the growers have learned basically correct, though crude, means of protecting their curing barns from unfavorable weather. Lowering the relative humidity in damp weather is sometimes accomplished by the use of open charcoal fires under the tobacco. During too much dry weather, "haying down" or excessively rapid dehydration is prevented by tightly closing the ventilators to maintain a higher humidity by stopping the circulation through the leaves.

The existence of these conditions would seem to indicate that the modern mechanical methods of air conditioning might well be utilized to increase the percentage of good tobaccos coming out of the curing process—and the practice has shown this to be true. The perfect curing conditions to be obtained through the use of effectively controlled air temperatures, humidities and circulation, have been used with marked success in promoting the light colors so desirable for the wrapper leaf. Extensive installations have not been made, however, because of the short season which exists for this work.

FIG. 2—INDIVIDUAL AIR CONDITIONING EQUIPMENT FOR THE RETAIL DEPARTMENT. BRINE LINES, WATER COOLING TANK AND AGITATOR PUMP PROVIDE REFRIGERATION FOR DEHUMIDIFICATION. FRESH AIR SUPPLY, UNIT AIR CONDITIONER (2500 C.F.M.), MAIN CIRCULATING FAN AND FIN HEATER INSTALLATION ARE ALSO SHOWN

After the completion of the curing process, the grower is forced, by the hygroscopic nature of his product, to wait for a period of damp weather before preparing his tobacco for market. Also, it is not at all unusual to find these producers more than anxious to make their deliveries to the buyer on moist days, realizing that the transportation of their product in dry weather can only result in a materially reduced weight.

Bayuk Cigars Incorporated, of Philadelphia, produce more than three hundred million cigars yearly and operate one of the largest and most scientifically designed factory buildings in the industry. They maintain a large and highly trained staff whose duty it is to instruct and assist the farmer in the most advantageous and modern practices for producing tobacco.

Humidified Warehouse

They have also extended their control over the fluctuations of weather by eliminating the practice of storing their tobaccos in the ordinary type warehouse, where the atmospheric conditions are out of control. To this end, they have recently designed and erected at Lancaster, Pennsylvania, a completely humidified warehouse, with a volume of 1,300,000 cubic feet and holding approximately forty thousand cases, or eight million pounds of filler tobacco. This large storage capacity insures the uniformity of their cigars against the possibility that one year's crop may not be up to the required standard.

The building is divided into fifteen rooms, with the air conditioning in each one furnished by a five thousand cubic feet unit humidifier. Compressed air controls are installed for both temperature and humidity. During cold weather, the hygrostat controls the humidity by admitting steam to the spray water and the temperature is raised by copper fin heaters installed as an integral part of the humidifier. During the summer, when natural high humidities prevail, the supply of spray water is automatically cut off and the unit continues in operation for circulation only. A recording hygrometer furnishes accurate record of the operation of each room, the average humidity being 65 per cent. While such a storage warehouse is decidedly an innovation, it has already

shown its practicability, since breakage of the tobacco leaves is eliminated and the desirable curing processes carried on by nature are given the most favorable conditions for development.

Tobacco Is Fermented

After this natural and unhurried procedure, taking from one to three years, depending on the type of tobacco and the conditions under which it was grown and cured, the material is fermented, in specially designed rooms, to develop the final flavor and aroma. In this work, Bayuk Cigars Incorporated have thirty-eight individual so-called "sweat" rooms, each under separate control for both temperature and humidity and with the ejector system of circulation. Careful record of dry and wet bulb temperatures is kept by recording instruments. Temperatures in these rooms range from 110 to 125 F and humidities from 60 to 75 per cent, dependent upon the particular tobacco under treatment. These conditions are maintained for an average period of six weeks—or until the desirable qualities are fully brought out.

This filler tobacco is now ready for shipment to the various plants where the Bayuk Tradition, Philadelphia, Havana Ribbon, Charles Thomson, Prince Hamlet and Mapacuba cigars are made. The central unit, with a capacity of 800,000 cigars daily, is located at Ninth Street and Columbia Ave., Philadelphia.

Air Conditioning the Factory

Air conditioning is provided for approximately 3,000,000 cubic feet in the Bayuk factories. More than two-thirds of this space is dehumidified by centrifugal type refrigeration. Operation of this important feature of the air conditioning system has been found necessary whenever the outside wet bulb temperature exceeds 70 F, a condition which often exists during the Philadelphia summer. A marked reduction in labor turnover results from the comfortable conditions given the machine operators through the use of dehumidification.

Where this refrigeration is provided, the building walls and roof have been completely insulated. The modern trend toward windowless buildings is evident in the main plant and, in fact, the structure has been compared by the cigar trade to a giant humidor. Windows are provided in the offices only, and then largely for psychological reasons.

Central station humidifiers are used, with suitable duct work and diffuser outlets over the general manufacturing areas. The usual rate of air supply is approximately one change in 12 minutes. Hygrostats and thermostats of the compressed air type controlling volume dampers and extended surface heaters are in use for control purposes.

Storage Departments

For some storage departments, the head system of humidification is used. In these cases, control is obtained by the use of electrical hygrostats and solenoid valves. For drying and other special purposes individual ejector systems are employed. Fourteen of these ejector systems are in use for filler drying with a combined daily capacity of more than 40,000 pounds of tobacco. Connections are provided on all these units for the supply of fresh, conditioned and recirculated air. All outside air which is not handled directly through the humidifiers is passed through sectional filters.

Applications of unit humidifiers have been made for unusual conditions and in some cases to add to the capacity of older central station systems which have become inadequate through load increases. Control for these special conditions is arranged through a variety of direct and reverse acting instruments which maintain the requirements of any particular department.

Preciseness of control maintained throughout the various stages of manufacture is shown by the fact that there are more than 40 separate controls and a similar number of recording instruments in service in the one building. These weekly record charts are carefully filed for future reference.

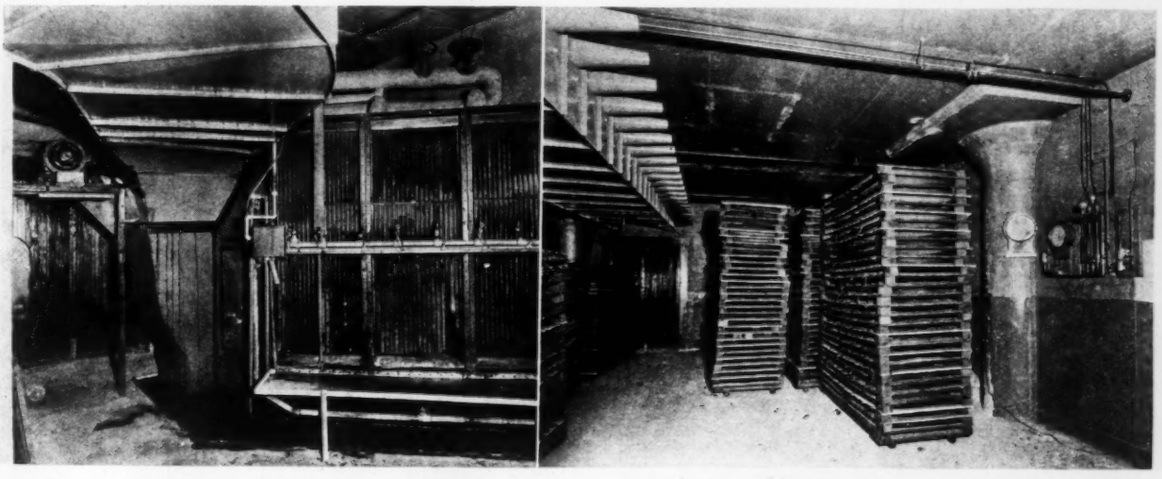


FIG. 3—(LEFT) HEATERS, MIXING CHAMBER AND FAN UNIT IN ONE OF THE EJECTOR DRYING ROOMS, BAYUK CIGARS, INC., PHILADELPHIA. FIG. 4—(RIGHT) EJECTOR DRYING ROOM INTERIOR, SHOWING CIRCULATING NOZZLES, CONTROL AND RECORDING ARRANGEMENT

Office Conditioning

The general and private offices are cooled by the central dehumidifying system during warm weather and, at other times, a regulated supply of filtered fresh air is circulated through the offices by an individual fan of 9000 c.f.m. capacity. Standard type diffuser outlets are installed in the duct work in the general office. In the private offices, the supply is delivered through grille work placed at the top of the columns and through circular outlets incorporated in the lighting fixture design. Return air from these private offices is taken through a plenum chamber to the main return duct. A thermostat located in this duct controls the temperature of the incoming air.

The cafeteria, shown in one of the illustrations, has an entirely independent system, which delivers approximately 10,000 c.f.m. of filtered fresh air to the dining room. One set of tempering coils is controlled by a thermostat in the air intake; another thermostat, located in the center of the room, controls the room temperature by admitting steam to a second set of extended fin coils. This air is exhausted through a duct system, collecting the air from over the various points at which cooking and baking are done.

With these facilities, it is immediately evident that perfect control of the air conditioning is possible and that the special conditions demanded by the fresh

FIG. 5—SECTION OF PACKING DEPARTMENT. NOTE COLOR-CORRECTING LIGHTS AND AIR DUCTS. THE HYGROSTAT, CONTROLLING CONDITIONS IN THIS SECTION, MAY ALSO BE SEEN

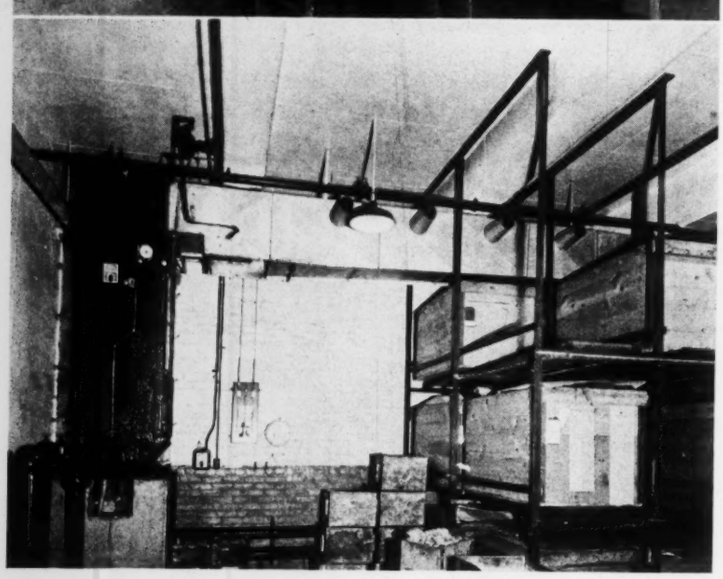


FIG 6—CONDITIONING ARRANGEMENT FOR MAINTAINING REQUIREMENTS OF BINDER STORAGE (68 TO 70 F AND 85 PER CENT RELATIVE HUMIDITY). NOTE INSULATED WATER LINES (52 F), 2500 C.F.M. UNIT CONDITIONER, RECIRCULATING DAMPER UNDER DUCT, AND EJECTOR DISTRIBUTION

work cigar machine method of manufacture may be adequately taken care of.

Manufacturing Processes

All filler tobacco is received in dry condition and must then be moistened to render it sufficiently pliable for removing the stem or midrib without breakage of the leaf proper. The binder tobacco receives a final fermentation in insulated fermentation rooms, which operate much like those described previously.

After these preparation processes, the tobacco is taken to the stripping departments, where the machines removing the stems are located. The filler tobacco, which is, of course, moist at this time, is later put through a drying process in the ejector drying rooms (shown in the illustrations). The effective

characteristics of this type of air circulation maintain an even rate of drying over the entire area. Particularly close control is used in this process, and an accurate record kept of all the conditions existing.

Because of the method of drying, the tobacco leaving this process is in perfect condition for use; but, to insure the absolute uniformity of the product, it is stored in bins for approximately two to three months before being taken to the cigar machines. During this time, the relative humidity required is approximately 70 per cent with normal temperatures. These bins are open on the ends and top and exact air conditioning is, of course, imperative during this long storage period. The dehumidification obtained from the refrigeration system is particularly valuable at this point. Because of the large areas of the leaf exposed, the excessively high humidities which prevail during the summer, where dehumidification is not provided, result in a tobacco which is entirely too soft for use in the cigar machines. The five hundred thousand pounds of tobacco, which the one factory keeps in this final conditioning process, are maintained at the correct condition regardless of outside weather.

Filler tobacco is then weighed out into the units to be issued to the cigar machines. These units are prepared one day in advance and placed in specially designed conveyor racks, with a separate ejector system under individual control for maintaining the correct conditions at this last step in the preparation.

Binder and Wrapper Tobaccos

Binder and wrapper tobaccos, which, as their names imply, have special purposes on the cigar, must be used in a more pliable condition and, therefore, the high moisture content at the time of stripping must be maintained through all stages of the actual making of the cigar. The old and common method of keeping this supply of moist wrappers and binders covered with wet cloths in an ordinary room is decidedly injurious. Heating and fermentation are the unavoidable outcome when these tobaccos are held over night or over week-ends, as a certain amount necessarily must be. The Bayuk method provides a separate cork-insulated room for each one of these two types of tobacco. Conditions in each room are maintained by a unit humidifier with refrigerated water being used in the sprays. By these means, the necessary high relative humidity is maintained and the dry bulb temperature is held below the danger point.

The atmospheric conditioning necessary during the actual rolling of the cigar is more or less familiar to the industry. The optimum of humidity, the writer believes, for this process is 70 per cent with a temperature of 72 to 78 F. A reduction of 2 per cent in the relative humidity will necessitate a complete readjustment of the entire cigar machine. The regain taking place when the humidity rises over 72 per cent will also disrupt the operating schedule. Practice has demonstrated that any sustained fluctuation of humidity, which can be recorded on the hygrometer, is also quickly recorded on the production sheets. It is, therefore, mandatory that some method of air conditioning be installed for this rolling process. This, of course, must be accomplished without discomfort to the operatives—a consideration which is often neglected.

Cigars, as taken from the manufacturing floors, are encased in the still moist wrapper and binder and, were they to be packed in the boxes in this condition, mold would undoubtedly result. The cigars are placed on a conveyor and passed, during the period of two days, through another ejector drying room under separate control. They then emerge at the discharge end in the proper condition for packing.

Color-correcting lighting units of five hundred watts each are used in the shading of cigars. The temperature rise occasioned by the heat given off from these units is compensated for by a corresponding supply of conditioned air to maintain the desired 65 per cent relative humidity in this department.

Practically all brands of cigars made by this company are wrapped in transparent material and this operation is not done by automatic machinery. This, too, necessitates an exceptionally close control on the humidity because of the breakage of too dry cigars and the poor work of the machines when the wrapping material itself is too moist.

After being packed in boxes, the cigars are conveyed to a final stamping and labeling room, which also has an ejector system under separate control to permit of the proper drying out of the packaging materials.

All Departments Should be Conditioned

Emphasis must be laid on the value of having all departments and rooms of a cigar factory under atmospheric control. The sensitive nature of the leaf makes it extremely susceptible to any change in environment and a single unconditioned step in the process will alter the correct moisture content which is so difficult to obtain.

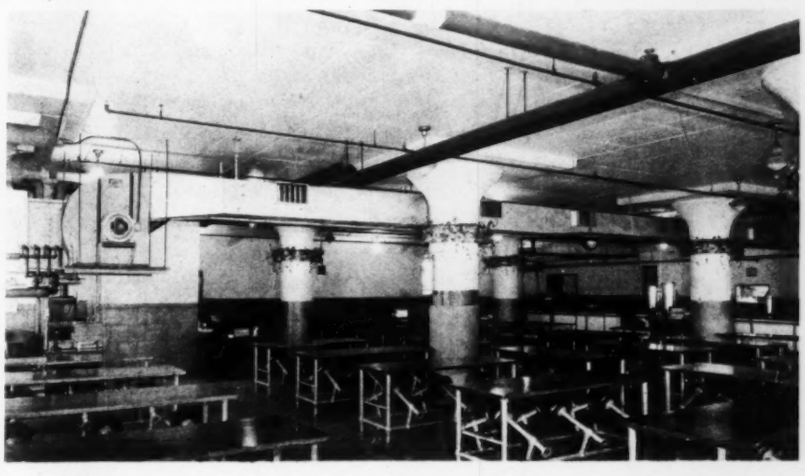
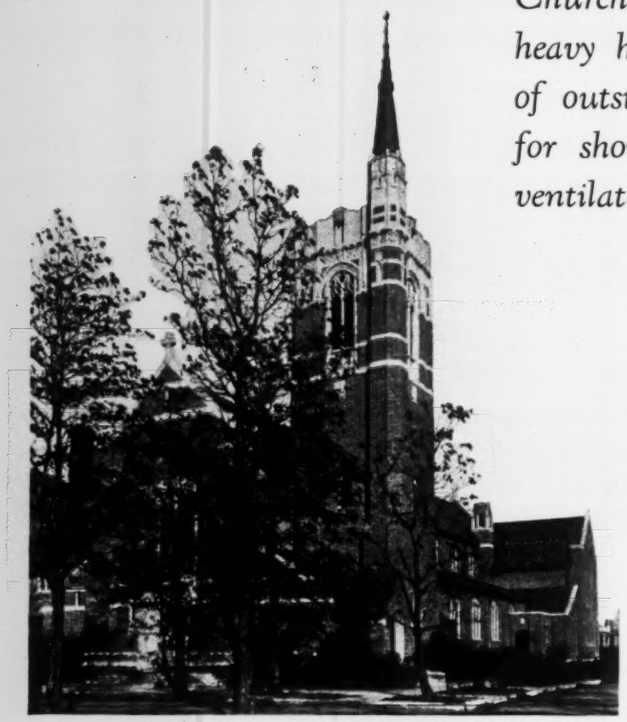


FIG. 7—THE CAFETERIA

Heating and Ventilating Churches



Churches usually have many windows and heavy heat loss through relatively great areas of outside surface, and are used intermittently for short sessions so that we must heat and ventilate churches, as contrasted with cooling and ventilating theaters

FUNDAMENTALLY, there would seem to be no particular difference between heating and ventilating churches and heating and ventilating theaters. Both are often lofty, with balconies; both have rather heavy occupancy per unit of floor area.

There is, however, a great difference in the heating and ventilating of churches and that of theaters. It lies in the fact that theaters are used day and night, and have no windows, with little heat loss, so that the proposition more truly stated is that we must usually *cool* and ventilate theaters.

Churches have many windows and heavy heat loss through relatively great areas of outside surface, and are used intermittently for short sessions so that we must usually *heat* and ventilate churches. Heating and ventilating a church, therefore, is a very different proposition from that of heating and ventilating a theater.

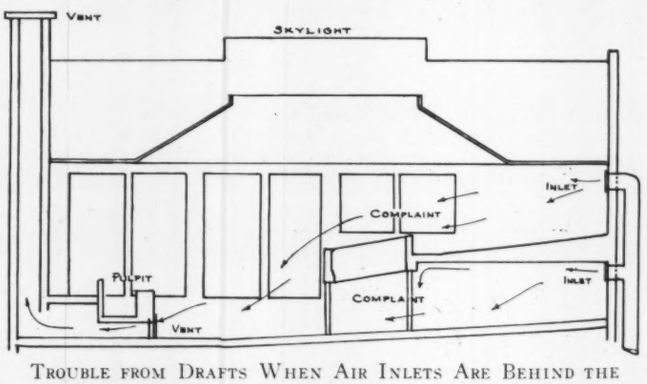
We must, of course, cool the atmosphere of churches on the many days when the sun and the heat given off by the audience cause a temperature rise. Usually enough cooling to offset this heat can be done by the gentle admission of large volumes of air only slightly cooler than the warm air.

Previously, the ordinary small town or country church was heated with a big wood-burning cast-iron furnace encased in brick work, with a floor register directly over the furnace and with long return-air ducts from floor registers in the remote corners of the room.

I remember repairing one of these furnaces, in Kansas City about 1898, which was then about forty years old. The plant gave pretty good satisfaction, too, and for all I know is still in service. This old plant illustrates the truth which, in these days of fans and steam heating, we may forget, that one can often get heat and air into a remote corner quite as easily by withdrawing from the corner the cold air, as by injecting hot air into it.

We have heated churches with the all-indirect system, blowing warm air in at the top of the auditorium, often through low-velocity grilles around the dome, exhausting it through flues with grilles close to the floor. While such plants operated fairly well, we found that they tended to overheat the balcony. I have noted, with these downward systems in lofty churches, a difference of ten degrees and more between the temperature at the rear of the balcony and that of the lower floor, this difference increasing when the weather outside was coldest. If the engineer attempts to heat such rooms quickly, introducing air, say, at 120 degrees, even greater temperature differences will exist between the lower parts and the higher parts, and the main floors will seem cold to the audience, and in truth they *are* cold.

The secret of success as to operation of a downward indirect heating system in a church is to put it in operation so many hours before the congregation arrives that the room will have been warmed comfortably, including furniture, floor, etc., and so that when the people do arrive, we begin to cool the room at once, introducing air at a temperature very little, if any, above the 68 degrees to 70 degrees desired. We have, in other words, to make the church simulate a theater, in which the incoming air

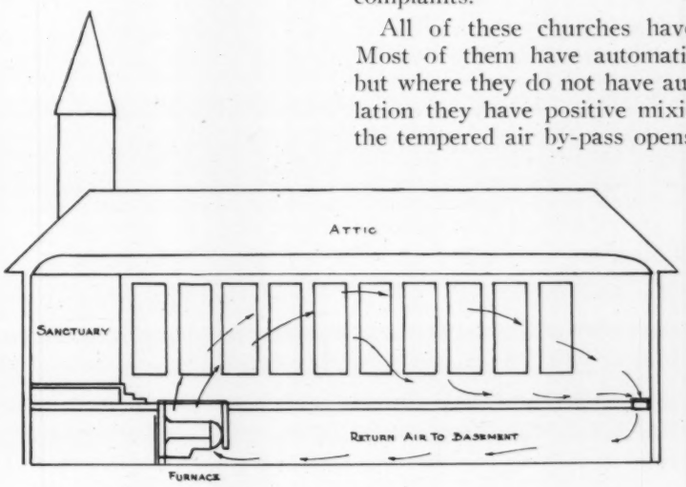


TROUBLE FROM DRAFTS WHEN AIR INLETS ARE BEHIND THE AUDIENCE

By Samuel R. Lewis

needs to be very little warmer than the air in the room, before we can make the downward system operate satisfactorily for the church.

Churches without large, cold windows and great chilly outside wall areas are very scarce, and experience proves that we cannot get the sexton to start the heating process more than an hour or so before the audience is expected. Therefore, it is in order to follow the lines of least resistance and to begin trying other methods or directions for air introduction.



Early Warm Air Heating of a Church

Introducing the Air

The least objectionable practice for church auditoriums is to bring the fresh air in through many low-velocity openings in the floor, letting it rise upward to exits through the ceiling, or through the lee-ward windows.

Successful plants are in operation with small floor registers under the pew ends, with mushrooms, and with hoods which deliver the air horizontally at right angles to the aisles, under the pews. Owing to the pew construction, there is less liability to draft-complaint by the people than there is where opera chairs are used, and cooler air can be introduced with less danger of discomfort.

The church heating plant which starts out on the basis of first warming the floor and furniture, not worrying so much about the temperature near the roof, starts with a very favorable condition. Almost anyone will endure chilly conditions for his face, his neck, his hands, with more tolerance than he will endure chilly conditions for his feet.

No Permanent Operating Force

One of the difficulties with the mechanical equipment of churches is that, as a rule, the operation by the sexton or fireman is not the most intelligent that could be desired. In addition, building committees come and go, as do custodians. There is no central supervising operating authority, as in a school system, and no consistent inheritance of the operating lore taught to the first fireman by the contractor.

Due to this unfortunate situation we find many efficient but elaborate church ventilating systems out of action, and we find some public tendency to decry mechanical ventilation, air conditioning and automatic temperature regulation for churches.

There are at least two solutions. One is to improve the supervision. Whenever I design an elaborate church plant, I resign myself to the necessity of re-visiting it about every three years to show the new custodian how to operate it.

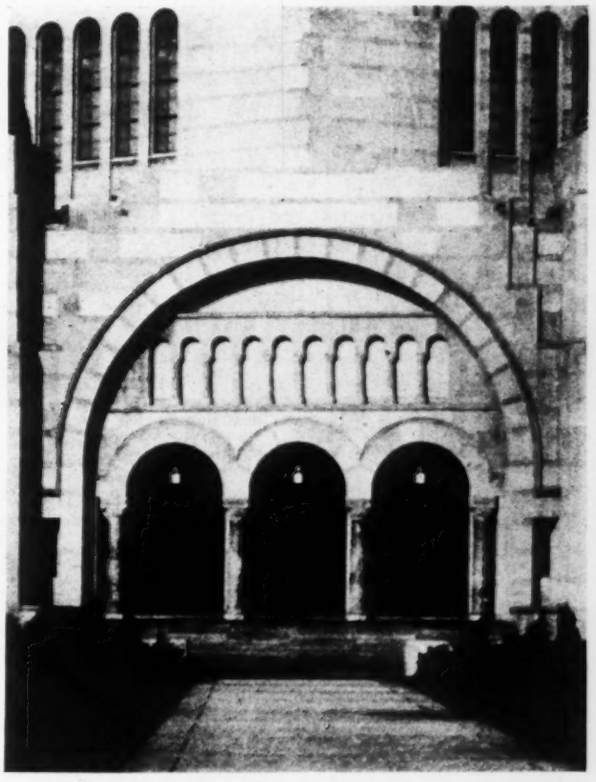
Simplicity Is Important

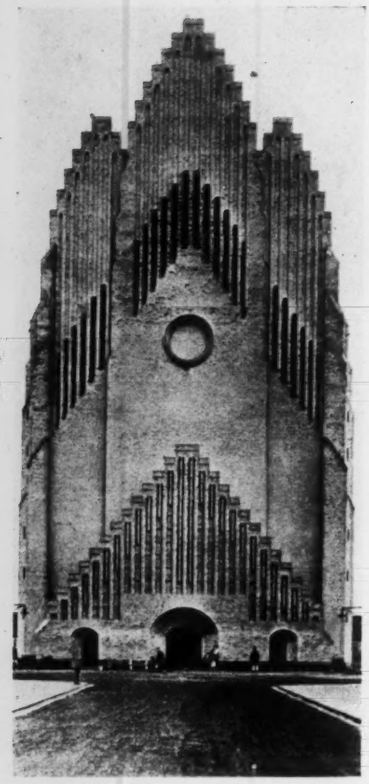
The other solution is to achieve the utmost in simplicity in the design of the plant, and to make its operation nearly obvious. Counting up some fifteen large churches designed in accordance with this effort toward simplicity during the past ten years, I have records of very few complaints.

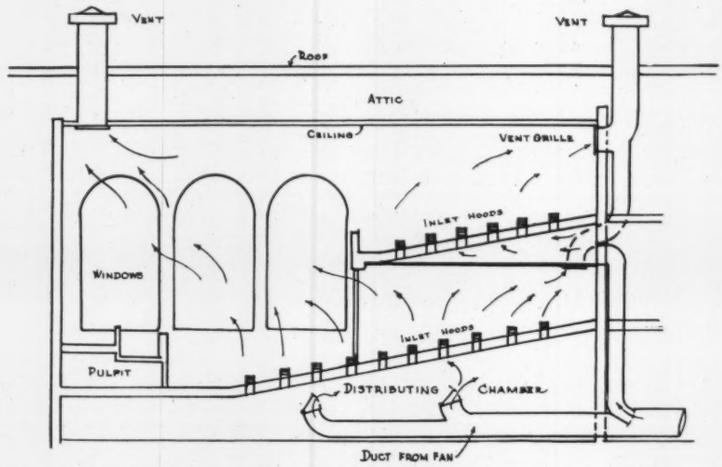
All of these churches have upward air circulation. Most of them have automatic temperature regulation, but where they do not have automatic temperature regulation they have positive mixing dampers so that when the tempered air by-pass opens, the hot air passage-area correspondingly closes, the dampers cannot be moved very rapidly or abruptly, and there is a well-lighted thermometer right there so that he who moves the dampers may mark the result.

Automatic Temperature Regulation

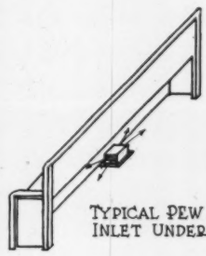
Where automatic temperature regulation is installed, there is provision so that the room thermostats, however they may strive to do so, cannot cause air cooler than a set temperature to enter the auditorium. Without this provision, the room having reached 70 degrees, the thermostats would ask for cool air, but that cool air might be so very cool that it would cause "draft complaints."

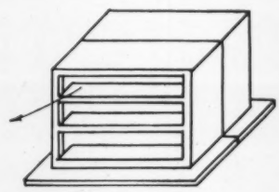






ABOVE—UPWARD INDIRECT VENTILATING SYSTEM IN A CHURCH. BELOW DETAILS OF INLETS



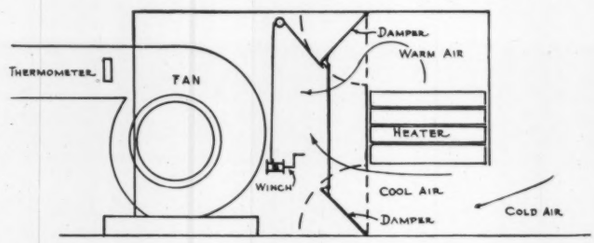


Temperature of Incoming Air

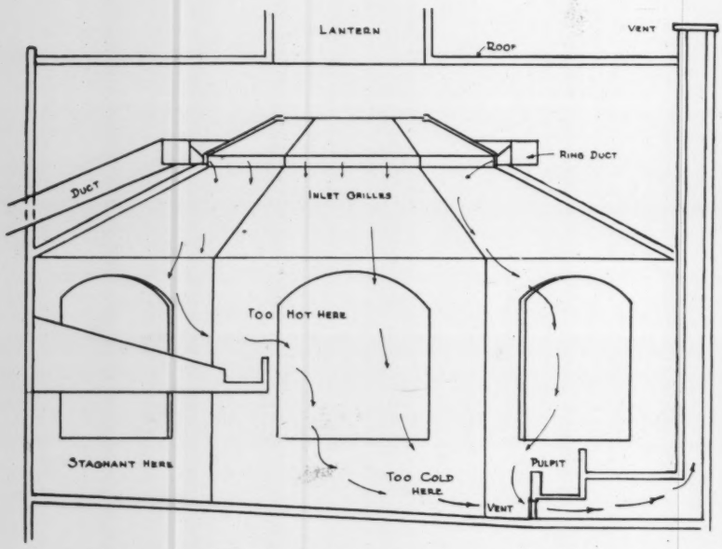
It is desirable never to introduce air into an audience chamber more than eight to ten degrees different in temperature from the air already in the room. We have not been able to discover any point of introduction or any delivery speed which would permit us to abrogate this rule.

With the upward system there may be direct radiators or not, as design and convenience may dictate. Many large church auditoriums do nicely without any direct radiators.

The upward system is especially well adapted for use with warm air furnaces.



POSITIVE MIXING DAMPERS



DOWNWARD INDIRECT VENTILATING SYSTEM IN A CHURCH

Heating and Ventilating Church Kitchens

Recently we have used the automobile radiator type of unit heater equipped with an electric fan behind a copper shell for church kitchens. It gives easy control, desirable air movement, clear wall space for tables, benches, etc., and is often more satisfactory than direct radiation. Its use is compatible with mechanical exhaust ventilation, which usually should be provided in church kitchens.

A goodly share of the spent air from the dining room ought to be exhausted from it through the kitchen in order that kitchen odors shall not enter the dining room.

If the kitchen has outside windows which can be opened, these will short-circuit, and will more than satisfy the demands of the kitchen exhaust so that kitchen odors may back up into the dining room. It is desirable, therefore, where the kitchen has any windows, to place booster

fans between the dining room and the kitchen, preferably at the kitchen ends of the ducts which lead from the dining room, near the ceiling. With such fans and ducts, even though the kitchen may have an excess air pressure over that in the dining room, due to open windows and wind pressure, the booster fan will overcome the difference.

The history of heating and ventilating plants in churches is very prone to be forgotten. We have, nearly all of us, been called to help out perplexed building committees who have lost contact, or confidence with, the designers or contractors, and who have even lost the plans under which the installation was made.

The practice of marking in paint on each fan its service, capacity and speed is commendable.

The practice of placing typed instructions, under glass and fastened to a wall, which cover the manipulation of fundamental dampers and valves, saves much of this lamentably missing contact and confidence.

There is no particular connection between these remarks on church heating and ventilating and the photographs of church buildings shown herewith. The author did not design the plants in any of these buildings.

Rand Tower, Minneapolis

A RECENT instance of pipe welding in heating systems is the new Rand Tower in Minneapolis, Minn., illustrated in Fig. 1, a beautiful twenty-five story building in the heart of the city's loop district. For six months three welders were constantly on the job, making approximately eight thousand welds in pipe, ranging in thickness from 1¼ inches to 12 inches in diameter. Not only was the pipe in the building welded, but the steam line in the street, conveying the steam to the building, was also a welded job.

Heat is supplied to the Rand Tower from the First National-Soo Building, about one-half block away. An underground tunnel 200 feet long conveys one 16-inch steam main, two 8-inch water lines, two 6-inch steam pipes and one 4-inch brass pipe from the First National-Soo Building to the Tower. All of the joints in the steel pipe are welded, and the joints in the brass pipe are brazed.

Overhead System Used

An overhead steam system is used, the steam being carried up through the center of the building in a 12-inch main, which is hung or supported at the eleventh story. There the pipe is reduced to 10 inches in diameter and this main continues to the top of the building. The outlets from these two main lines are all welded. Branches are run straight down to the first floor and radiator branches are taken off at each floor.

The holes for the radiator branches were made by the use of a "hole saw." This "hole saw" is attached to an electric drill and a hole of the diameter required, namely, 1¼ inches, is quickly sawed or cut in the big main pipe. Either a coupling or a nipple, as the case may be, is then welded into the pipe. One man cuts the holes with the saw and the welder follows him, welding either nipples or couplings in place. The steamfitters then continue the small branch lines to the radiators with threaded and coupled pipe.

None of this radiator piping, or in fact piping of any kind, is exposed. All of the pipes in the building have been placed in the walls and have been bricked in. After all welds were made in certain sections of the pipe system, an air test was placed upon the pipe of 300 pounds per square inch. All told, out of 8,000 welds there were less than a dozen leaks.

Keeping Roof Drains Open

The job was not installed exactly in accordance with the original plans. Toward the top of the building there were exposed projecting roof sections where the building was set back from the building line. In a climate like that of Minneapolis, these projecting roof sections would fill with snow and ice and the drain would be useless for many months of the year. The roof drain and the heating arrangement are shown in Fig. 2. The

FIG 1—THE RAND TOWER

2-inch steam line forms a straight sided U-bend around the roof section, which is welded at each corner. This steam pipe is exposed on the roof and keeps the snow and ice from forming so that the drain will work.

Expansion Joint

Fig. 3 shows another unique feature of the building, an expansion joint built in the wall. The joint is placed in a 6-inch riser, extending upward in the center of the building alongside the 12-inch main steam pipe. This is a view of the main pipe well in the center of the building about the eleventh story. A weld is

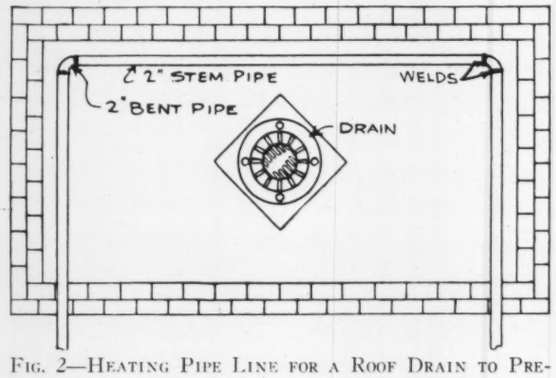


FIG. 2—HEATING PIPE LINE FOR A ROOF DRAIN TO PREVENT ICE AND SNOW FROM FORMING AND BLOCKING THE DRAIN

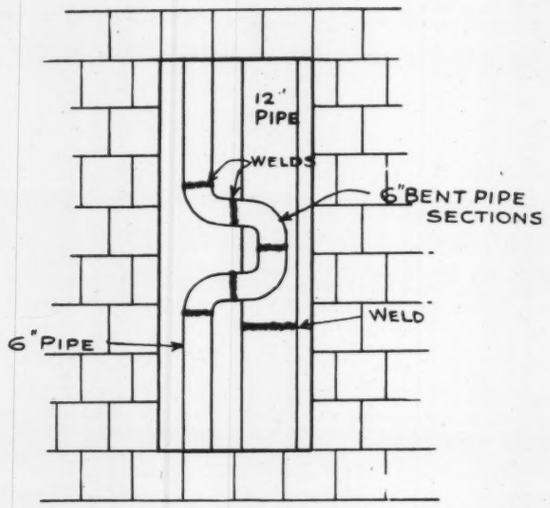


FIG. 3—EXPANSION JOINT FOR A SIX-INCH RISER. THIS VIEW OF THE MAIN PIPE WELL ALSO SHOWS THE 12-INCH LINE

shown in the main 12-inch pipe line, but the principal feature of the sketch is the U-bend in the 6-inch riser, consisting of a bent pipe section joined together by five

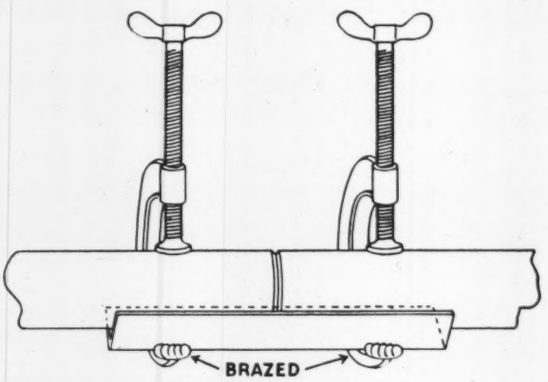


FIG. 4—A CLAMP USED TO HOLD THE PIPE IN POSITION FOR TACK WELDING

welds. This construction is very flexible and takes care of the expansion and contraction in the 6-inch line.

A Handy Clamp

As usual, such a job develops some handy tools. A tool or jig of this kind is illustrated in Fig. 4. This consists of two C clamps, which are very common in connection with welding, brazed to an angle iron to make a jig to hold pipe in line while it is being tack welded. When the pipe is tack welded, the jig is removed without difficulty and the weld is completed all the way around the pipe.

Designing and Constructing Expansion Bends

By G. W. Hauck*

IN THE preparation of piping layouts, increasing attention is being directed to means for providing flexibility and compensating for expansion and contraction. Pipe bends have many uses, such as reducing the number of joints in a line, avoiding building obstructions (columns, foundations, etc.) and reducing friction; however, their principal use today is to compensate for expansion and contraction in pipe lines. It is the purpose of this article to develop some methods of calculation and application in problems relating to such use.

Factors to Consider

A number of engineering problems are encountered in designing piping systems where bends are used to provide flexibility and to compensate for expansion and contraction by depending upon the elasticity of the pipe for the necessary movement. Some of the factors to be considered in the design and selection of bends to produce desired results are the weight of the pipe, radii, type or design of bends and the amount of expansion. Bends must be designed and the type selected for each particular problem or installation and, while there exist exhaustive formulae, the exact basis of calculation can be readily obtained from the simple data following and given in table form.

Amount of Expansion

After the size of the line, working pressure, velocity, etc., have been determined, the first consideration is the amount of expansion to be taken care of in the various lines or runs of piping. To determine the amount of expansion, Table 1 should be used.

Table 1 gives the increase in length of steel or wrought iron pipe in inches per hundred feet. The linear expansion and contraction for any length of pipe may be found by taking the difference in increased length at the minimum and maximum temperatures, dividing by one hundred, and multiplying by the length of line under consideration. For example, what is the expansion of a steam line constructed of steel pipe, under a steam working pressure of 150 lb. gage, 100 F superheat, 60 feet long, with a minimum room temperature of 60 F.

Referring to steam tables, we find the temperature of steam at 150 lb. gage to be 366 deg. and this plus 100 deg. superheat gives a total temperature of 466 F. Deducting 60 F minimum from 466 F maximum, we get a temperature difference of 406 F. Using the table, we find the expansion for steel pipe at 400 F equals 3.45 in. per hundred feet, hence $3.45 \times 60 \div 100 = 2.07$ in for 60 feet.

* Crane Co., Cincinnati, Ohio.

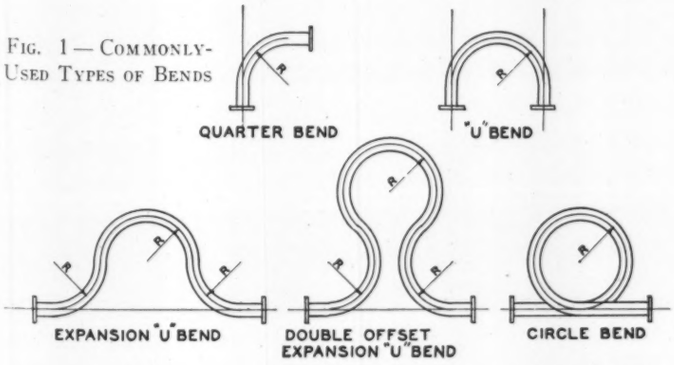


FIG. 1 — COMMONLY-USED TYPES OF BENDS

Type of Bend to Use

The next consideration is the type of bend to use and this is usually determined by conditions of space, etc.

Fig. 1 shows the more commonly used types of bends and Table 2 gives reliable data on the expansion value of pipe bends. The figures given are in inches for the expansion cared for by quarter bends.

The figures in Table 2 are for quarter bends (see Fig. 1).

For U-bends, multiply expansion values by two.

For expansion U-bends, multiply expansion values by four.

For double offset expansion U-bends and circle bends, multiply expansion values by five.

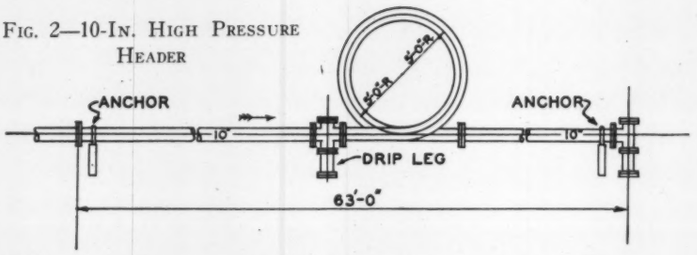
When bends are sprung cold a distance equal to the figure given in Table 2, they will take care of twice that figure in inches of expansion.

The following problems are given to illustrate the uses of the data.

A High Pressure Steel Pipe Header

Fig. 2 shows a 10-in. high pressure steel pipe header operating at a total temperature of 725 F with a minimum room temperature of 60 F at night when shut down, making a total temperature difference of 725 — 60 or 665 F. Referring to the expansion table, it is found that at 665 F the expansion would be practically 7 in. per hundred feet for steel pipe, hence the expansion for this header would be $7 \times 63 \div 100 = 4.41$ or practically 4-7/16 in. To equalize the strain, whether hot or cold, the pipe in this header was cut short 2-3/16 in., to spring the circle bend cold that amount. Referring to the table giving expansion data of bends, we find that a 10-in. quarter bend with a 60-in. radius takes care of 7/8 in. of expansion and this multiplied by five gives 4 3/8 in., and allowing 4 3/8 in. for cold springing, this circle bend can actually take care of 8 3/4 in. expansion. As the expansion of the header is only 4-7/16 in., a considerable factor of safety was provided.

Fig. 2—10-In. High Pressure Header



While for this particular problem a radius of 50 in. could have been used, which develops a bend capable of caring for 6 1/4 in. of expansion, the increased radius provided additional flexibility at very little added cost, and therefore was used. In using this type of bend in a vertical position, provision for draining must be made, as shown in Fig. 2. A cross with drip leg ahead of the bend is shown, the arrow indicating the direction of flow. The circle bend installation shown is in actual service under 415 lb. pressure and has proved ample for more than two years.

Table 1—Expansion of Pipe. Increase in Length in Inches Per Hundred Feet

Temperature, F	Steel	Wrought Iron
0	0	0
20	.15	.15
40	.30	.30
60	.45	.45
80	.60	.60
100	.75	.80
120	.90	.95
140	1.10	1.15
160	1.25	1.35
180	1.45	1.50
200	1.60	1.65
220	1.80	1.85
240	2.00	2.05
260	2.15	2.20
280	2.35	2.40
300	2.50	2.60
320	2.70	2.80
340	2.90	3.05
360	3.05	3.25
380	3.25	3.45
400	3.45	3.65
420	3.70	3.90
440	3.95	4.20
460	4.20	4.45
480	4.45	4.70
500	4.70	4.90
520	4.95	5.15
540	5.20	5.40
560	5.45	5.70
580	5.70	6.00
600	6.00	6.25
620	6.30	6.55
640	6.55	6.85
660	6.90	7.20
680	7.20	7.50
700	7.50	7.85
720	7.80	8.20
740	8.20	8.55
760	8.55	8.90
780	8.95	9.30
800	9.30	9.75

600 Ft. Steel Pipe Line

Fig. 3 shows a 6-in. steel pipe line 600 feet in length, carrying 225 lb. saturated steam pressure in outdoor service, where the minimum temperature was figured as zero. The temperature of saturated steam at 225 lbs. is 397 F and this represents the total temperature change for this pipe line. Using the table, we find that at 400 F the expansion of steel pipe is 3.45 in. per 100 feet or $6 \times 3.45 = 20.7$ in. total expansion for the 600 feet of length. The total length of pipe should be cut short 10.35 in. and this 10.35 in. divided into the three sections and between the anchors, cutting short $10.35 \div 3 = 3.45$ in. or practically 3-7/16 in. in the piping of each section. Each of the three bends would be sprung cold 3-7/16 in. by cutting the adjacent piping short that amount.

To determine the radii of bends, etc., we will assume that expansion U-bends are to be used to avoid excessive space requirements. Referring to the table, we find that a 6-in. quarter bend with 50-in. radius will take care of 1-in. expansion and this multiplied by four gives a normal expansion value of 4 in. for an expansion U-bend or 8 in. total for the bend when sprung cold 4 in. This indicates that three such bends will take care of 24 in. maximum expansion, which is slightly in excess of the requirement which calls for bends to take care of 20.7 in. expansion. These 6-in. bends would each require about 27 ft. 4 in. of pipe, which is commercially practical.

For this same problem it woud be possible to work out two double offset expansion U-bends; however, this would develop radii of about 52 in., requiring over forty feet of pipe per bend, which is not commercially practical and, in addition, such bends would require excessive space for installation. This indicates that the use of three expansion U-bends is correct and the more practical for this particular installation. A certain amount of checking and ingenuity must be employed in the solution of these problems and in selecting the most suitable type of bends.

A Two-Boiler Job

Fig. 4 shows the boiler leads, header and branch piping for a two-boiler job and indicates the means provided

TABLE 2—INCHES EXPANSION CARED FOR BY QUARTER BENDS

SIZE OF PIPE INCHES	MEAN RADIUS OF BEND INCHES												
	12	15	20	30	40	50	60	70	80	90	100	110	120
1	¼	⅜	¾	1¾	3⅛								
2	⅛	¾	½	1	1¾	2¾	3⅞	5⅜					
2½		¼	⅜	⅞	1½	2¼	3¼	4½	5¾				
3		⅛	⅜	⅝	1⅛	1⅞	2⅝	3⅝	4¾	6			
3½			¼	⅜	1	1⅝	2⅜	3⅛	4⅛	5¼			
4			¼	½	1	1½	2	2⅞	3¾	4¾	5¾		
4½				½	⅞	1⅜	1⅞	2½	3⅜	4¼	5¼		
5				⅜	¾	1⅛	1⅝	2¼	3	3¾	4⅝	5⅝	
6				⅜	⅝	1	1⅜	1⅞	2½	3⅛	3⅞	4¾	5⅝
8					½	¾	1	1½	1⅞	2½	3	3⅝	4⅜
10						⅝	⅞	1⅛	1½	2	2⅜	2⅞	3½
12							¾	1	1⅜	1⅝	2	2½	2⅞
14								⅞	1⅛	1⅜	1¾	2⅛	2½
15									1	1⅜	1⅝	2	2⅜
16									⅞	1¼	1½	1⅞	2¼
18												1⅝	1⅞
20													1¾

for flexibility of piping and taking care of the expansion and contraction. For this job, steam at 175 lb. pressure with 100 deg. superheat is used, which gives a total temperature of 477 F. Figuring the minimum room temperature at 40 deg., we get $477 - 40 = 437$ F total temperature change. Referring to the table, we find that at 440 deg. steel pipe expands 3.95 in. per 100 feet. Referring to Fig. 4, it will be observed that the short welded header is anchored to the wall on brackets, further that the 6-in. branch is anchored at another wall which is to the left and at a right angle. This anchoring forces the bends to take care of the expansion in the various lines and the anchors direct the expansion in the proper directions.

Between the boilers and header, the expansion is taken care of in the two 4-in. bends between each boiler and the header. In the 6-in. branch piping, the expansion is taken up by the two 6-in. quarter-bends, one at each end of the run of branch piping. This run of 6-in. branch piping is 40 feet long, which develops a total expansion of $3.95 \times 40 \div 100 = 1.58$ in. or 1-9/16 in. Therefore, this run of pipe was cut short half that amount, or practically 1-3/16 in. One 6-in. quarter-bend with 36 in. radius will take care of ½ in. expansion (by interpolation in table) and the other 6-in. quarter bend with 48 in. radius will take care of ⅞ in. expansion, giving the two bends a total expansion value of 1⅜ in. plus the same amount for cold springing, or a total of 2¾ in., which is in excess of the requirement, i. e., 1-9/16 in. The distance center-to-center between boilers and headers is 16 ft., which develops a total expansion of $3.95 \times 16 \div 100 = 0.632$ or practically ⅝ in., therefore, these runs of piping were cut short 5/16 in., half the amount of expansion and contraction movement. The one 4-in. quarter-bend with 30-in. radius will take care of ½-in. expansion and the other quarter-bend with 36 in. radius will take care of about ¾ in., giving the two bends a total expansion value of 1¼ in., which is more than ample for the condition when sprung cold five-sixteenths of an inch.

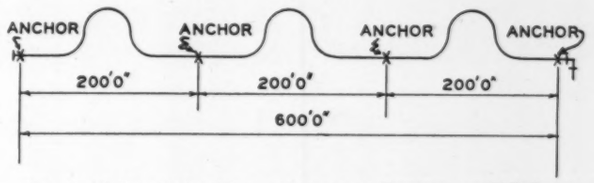


FIG. 3—6-IN. STEEL PIPE CARRYING STEAM AT 225 LB.

Drips and Drains

It is interesting to note in passing that Fig. 4 shows the application of some of the author's suggestions given in "Drips and Drains," published in the April, 1930, HEATING, PIPING AND AIR CONDITIONING, pp. 305-6. The header is shown with two welded drip pockets 15 in. long directly under the boiler leads and connected to a trap. The three gate valves above the header have tapped bosses with globe drip valves above the boiler room floor for draining the condensate, which collects above the valve discs when shut down.

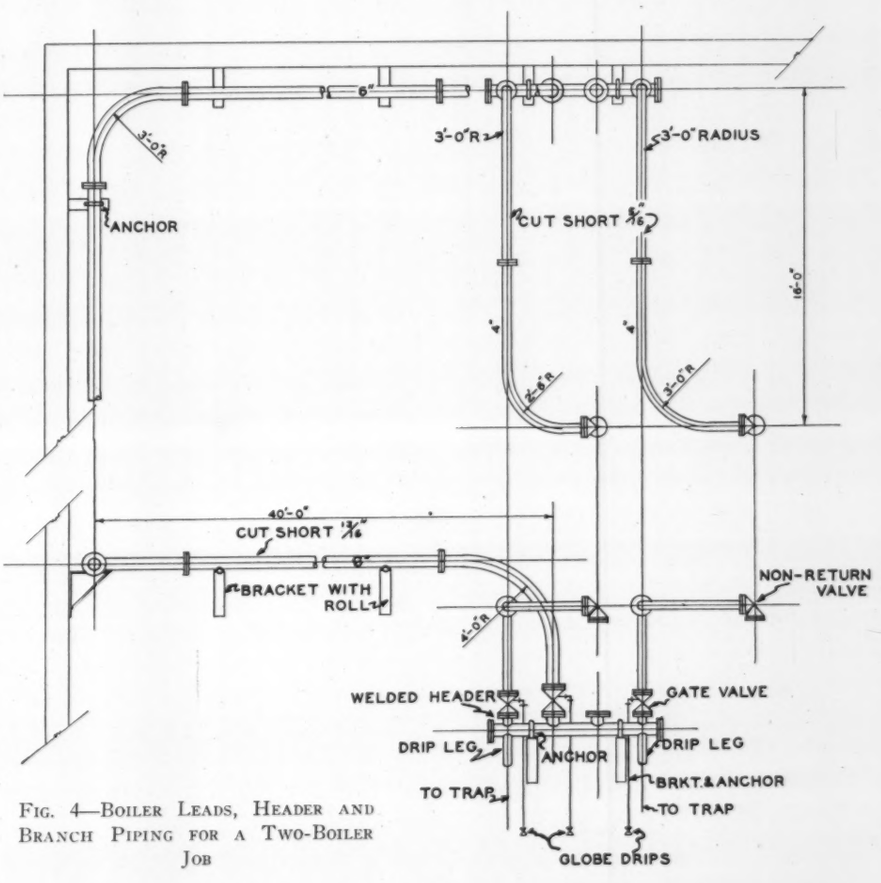


FIG. 4—BOILER LEADS, HEADER AND BRANCH PIPING FOR A TWO-BOILER JOB

Location of Anchors

In designing pipe lines where provision is made for taking care of expansion and contraction, particular attention must be given to proper location of anchors. Unless properly anchored, the expansion may not take the direction intended or in the bend provided. Figs. 2, 3 and 4 indicate the location of anchors to force expansion into the bends provided.

Particular attention is directed to the anchor arrangement shown in Fig. 3, where the long run is anchored at each end and between bends, which makes each bend take care of an equal amount of the expansion and contraction. Several manufacturers have varied and complete lines of brackets, roll supports and anchors which can be utilized on almost all jobs.

It is frequently advisable to use a certain number of double roll supports, with one roll below and the other roll above the pipe, to maintain alignment. Often anchors should be stayed from the sides through tie-rods extending diagonally to the wall and with turnbuckle adjustment. Provision for this is made on many types of brackets and anchors.

Wherever bends are used for expansion purposes, the flanges should be of steel and never of cast iron, as the latter will crack when subjected to expansion strains. Where welded construction is used, bends can be obtained with plain ends and beveled for welding directly into pipe lines.

Lengths of Pipe for Bends

Exhaustive tests by manufacturers on extra strong and standard weight pipe check closely; therefore, in all calculations the expansion value of bends of corresponding shape and size can be considered the same for standard and extra strong pipe.

In designing bends a further precaution is suggested—keep within the commercial lengths of pipe obtainable. Steel pipe, both standard and extra strong, can be obtained in double random lengths of about thirty-nine to forty feet maximum length in sizes ¾ in. to 12 in. inclusive. Genuine wrought iron pipe can be obtained in random lengths not over twenty feet. Therefore, care must be used to keep within these limits of length, where possible, to avoid joints in a bend. Where the radius and size of a bend make a joint, or number of joints necessary, care must be exercised to locate these joints where the least strain will be encountered.

The Age of Air Conditioning

The air conditioning applications of today promise conditioned air tomorrow for the scene of practically all human activity

By W. G. Hillen*

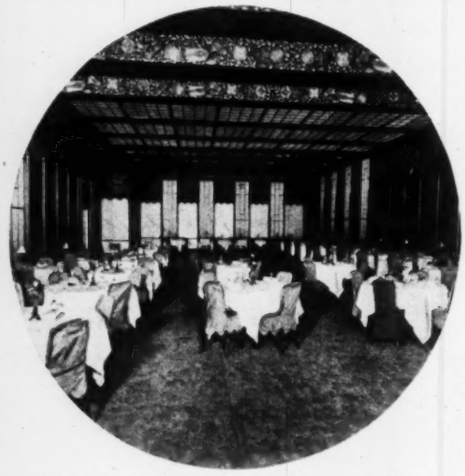
WE *ARE* air conscious. Too long have we, as engineers, been saying: "The country is becoming air conscious."

That phrase was well used five years ago, but the air conditioning of theaters, which started as a novelty, is today a necessity. The great masses of people attending picture shows, ever on the alert for something new, have discovered air conditioning, have found that weather can be controlled, that they can be comfortable both summer and winter. As a result, air conditioning is today as essential as the talkie mechanism in filling the house, in making money for the owner.

Advertising about air conditioning is now reaching people in all walks of life, in addition to the engineering and contracting interests.

Through this advertising, everyone has been awakened to the fact that air conditioning is a reality, that it has solved the industrial manufacturing air problems of approximately two hundred industries, that it has given correct atmospheric conditions to the largest department stores in the country, to banks, dance-halls, restaurants, public buildings; that it has made possible the sound insulation of moving-picture studios and radio broadcasting stations.

We are all conscious of what has happened in the past. Have we looked into the future to see what it might hold? What changes will take place in public buildings in the years to come?



A Restaurant and Dance Floor in Which Air Conditioning Has Been Supplied for the Comfort of the Occupants

Eliminate Windows

Can't we see ourselves gradually relieved of the necessity of windows? Windows have always been used for one reason—to admit light. Going back to life in Egypt, we find that whatever light entered the temples did so indirectly by reflection. With the coming of glass, windows were built to let light enter directly, and yet, in the brilliant southern countries, the windows were but slits in the walls. Coming up into France and England of less brilliant light, we

* Director of Educational Training, Carrier Engineering Corp.

A Building in Which a Complete Air Conditioning System Has Been Supplied for All Offices

find the Gothic era ushering in its spirit of freedom with massive windows, to let in the light. So the window has played its necessary part in the history of man, through the age of oil-lamp, taper, gas-light and the primitive electric light.

Some fifty years ago, on October 21, 1879, when Edison made the first practical electric light, many feel he started the passing of the window and natural light for the more scientific basis of artificial lighting.

What have been the disadvantages of windows which we have tolerated for their light? The largest factors in our heating or cooling load for air conditioning have been transmission, sunlight and infiltration. The elimination of windows means the elimination of the greater part of this load.

How satisfactorily have windows served their purpose for the giving of light? The source of light during the day is ever-changing in position and intensity, with the accompanying variation of intensity of light inside. We are forced to supply lights for night, and some times day, use.

Ordinary window glass has never passed the necessary ultra-violet light to the inside. You might say: "Neither will the wall," but at least the wall will keep out the infiltration of germ-laden dust.

Of what value are windows today in our congested areas, but to enable us to see other windows? We have been hearing much of the possible de-ionization of air by passing it over heaters. If this is so, then surely we of this scientific age are capable of re-ionizing the air and obtaining it more uniformly under control, than we do from the sun.

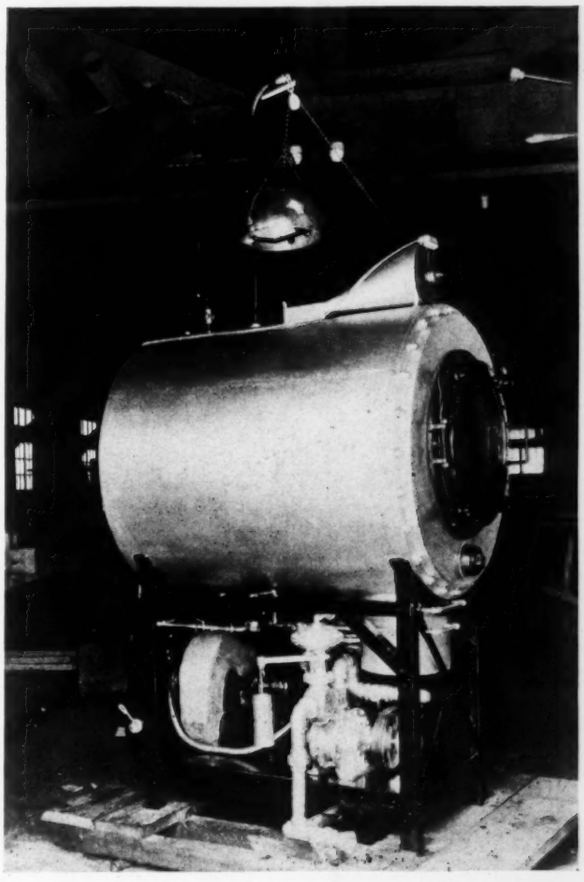
In New York, for a number of the winter months, we do not receive any ultra-violet light from the sun; at least, tests indicate that fact. This using of windows for light has caused the use of courts, with the absolute loss of valuable ground space, which should be rentable office space. Therefore, it is conceivable that economic necessity will force office buildings into the elimination of windows, the introduction of air conditioning and ultra violet light.

Treating Diseases

What will the future bring for the comfort of patients in hospitals? What will it bring in the treatment of some diseases by air conditioning?

Do we know today what effect some parts of the country have in the successful treatment of certain diseases? Is it because of the intense ultra-violet rays of the sun? Is it because of the rarefied atmosphere with the consequent deeper breathing required? Is it because of the dryness or moistness of air, or the uniform conditions of the weather throughout the year?

Shall the future bring laboratory determinations of the effect of air conditioning in the treatment of some diseases? Today a conditioning cabinet has already been built for the University of California for research with bacteria. This cabinet will not only maintain variable temperatures and relative humidities, but pressures above



A Complete Conditioning Cabinet, Giving Not Only Variation of Temperature and Humidity, but Also Varying Pressures and Ultra-Violet and Infra Red Light

and below atmospheric as well. Ultra-violet and infra red light can be introduced into this cabinet. Will the future bring the same type of room, for testing people and their diseases?

Halls, Ocean Liners, Mines, Hotels

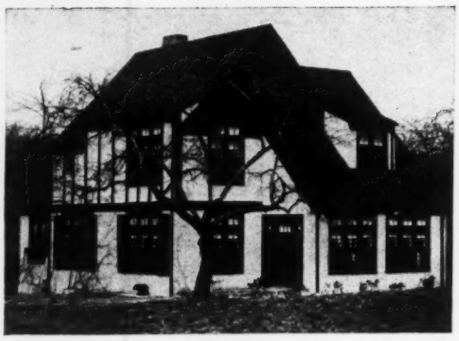
Can we imagine air conscious America tolerating the almost unbearable convention halls of recent memory? Already convention halls have arisen in New York and Chicago among other places, air conditioned, and relieved of the intolerance of the weather.

Can we safely predict air conditioning for our ocean liners? Anyone who has traveled near the equator knows of the difficulty of sleeping, because of the humid conditions.

Air conditioning will take its place in the development of mines to deeper levels. Even today, a system is being installed in South America, enabling a mine stopped at the one-mile depth, because of the intolerable air conditions, to be worked to a 2½-mile depth. For the first time, fans, dehumidifier and refrigeration machine are to be placed one mile below sea level.

What of the future of air conditioning for hotels? Today dining rooms, grill rooms, reception rooms, lobbies are conditioned. How much longer will it be before all the rooms in hotels are conditioned?

I doubt if a hotel can offer anything more desired or better than a good night's sleep. Air conditioning will guarantee that night's sleep, summer as well as winter. The cooling effect will be controlled individually, giving whatever effect is desired. Windows can be kept closed, and instead of breathing the dirty air that comes through the open window from the outside into most hotel rooms, the air will be properly heated or cooled, humidified or dehumidified. The dirt will be removed, and the air motion will be uniform and unnoticeable, and not dependent upon the pranks of the wind.



An Air-Conditioned Home

For the Home

How much longer before air conditioning in the home is widespread? Today equipment is on the market for the home, for heating, humidifying, cleaning and properly distributing the air.

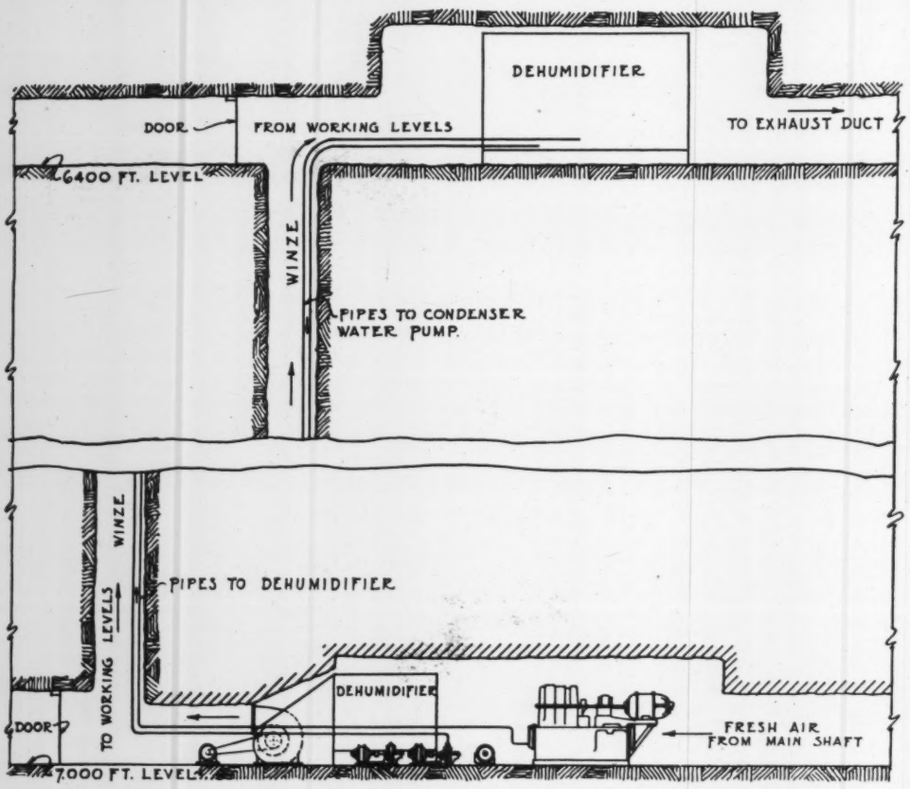
Who can doubt that air conscious America, realizing the benefits of air conditioning in the theaters and offices, will demand it in their homes?

How long will it be before cooling and dehumidification in the home in the summer will be considered as necessary as heating and humidification in the winter?

When will we have a comfort zone chart for persons at rest—sleeping? It is recognized by some authorities today that air of comparatively high relative humidities, is a soother of the nerves, and that air of comparatively low relative humidity is a stimulant to the nerves. Is this not proven in life? How much easier it is to sleep on a cool rainy night, as compared to a hot dry atmosphere.

I have already heard of industrial plants having air conditioning, where employes during the summer had requested the management to allow them to come back and sleep at the plant at night, because of the comfortable conditions. When people are willing to do that, how long will it take people to realize the advantage of conditioning in the home?

When one stops to think about it, the future of air conditioning is manifold, and one can agree with a recent address over the radio in which the speaker said that radio, aviation and refrigeration hold the promise for the greatest development in the future.



A Cross-Section of a Typical Installation for Conditioning a Mine

Investigation of the Heat Insulation Properties of Building Construction

By H. Krueger and A. Eriksson. *Reviewed by* J. C. Peebles*

IN A previous issue we presented a review of an earlier† work by the same authors, discussing the equipment and methods used by Swedish engineers in their investigations in the heat transmission of building materials. The later volume gives the results obtained from a study of a considerable number of building materials, arranged in several different types of construction. It is our purpose here to examine the results obtained by the authors and, in so far as differences in materials and types of construction will permit, to compare these results with those current in American engineering practice.

The conductivity values for concrete construction, frame construction, brick walls, and windows as determined by recent investigations are given in this article. The investigations also included two tests on cork.

In investigations of this kind there are four factors which enter into the problem, all of which may be determined from properly conducted tests. Arranged in order of the importance which the heating engineer attaches to them, these factors are as follows:

1. Air to air heat transmission, usually expressed in Btus per hour, per square foot of surface, per degree fahrenheit of temperature difference between inside and outside air. This factor is usually represented by the letter U.

2. Surface to surface heat conductance, expressed in Btus per hour, per square foot of surface, per degree fahrenheit of temperature difference between the opposite surfaces of the construction under test. In the case of homogeneous materials the conductance is usually expressed per inch of thickness, and represented by the letter C. For non-homogeneous materials and also for thin materials such as glass, building paper, etc., the conductance is expressed for the *actual* thickness under consideration, and is usually represented by the symbol C_u.

3. Inside surface factor, expressed in Btus per hour per square foot of surface, per degree fahrenheit of temperature difference between the inside surface of the wall (or whatever the construction may be) and the inside air. This is simply the rate at which the inside surface absorbs heat, and is usually represented by the symbol K_1.

4. Outside surface factor, expressed as above, except that the temperature difference concerned is that between the outside surface and the outer air. This is the rate at which the surface emits heat, and is usually expressed by the symbol K_2.

† This refers to a record of investigations in Sweden of heat transmission through building materials. Those which comprise this record were made available to this publication through the kindness of P. Nicholls, U. S. Bureau of Mines, Pittsburgh, Pa.

* Armour Institute of Technology.

Results for Concrete Construction

All the above factors have been evaluated in the investigation conducted by the Swedish engineers. In Table 1 below we present some of the results which they obtained on various types of concrete construction. Since concrete mixtures vary widely, not only in the proportions used, but also in the nature of the aggregate, the density of the material, expressed in pounds per cubic foot, is perhaps as good a guide as any in estimating its nature. The density is given in the table below, in column headed d, and also the thickness in inches, in column headed t.

The figures given will serve to present a fair idea of the results obtained. The odd dimensions given, particularly in the thickness, are due to the fact that the authors have employed metric units throughout, which must be converted into our system in order to make comparison possible. Where blanks appear in the table, this particular data has been omitted by the authors.

Table 1

Heat Transmission of Concrete Walls

Nature of Construction	t	d	K_1	K_2	C_u	U
1. Porous concrete	5.9	62.2	1.53	1.10	0.34	0.22
2. Porous concrete, finished on both sides with lime plaster	6.7	62.0	1.63	1.04	0.345	0.22
3. Crushed brick concrete...	5.9	93.5	....	....	....	0.41
4. Same as above, finished on both sides with lime plaster..	6.7	93.5	1.77	1.37	0.64	0.35
5. Porous concrete, containing powdered slate.....	5.9	50.0	1.24	1.06	0.27	0.183
6. Same as above, with plaster on cold side and paper on warm side	6.3	....	1.38	0.96	0.267	0.179
7. Hollow cinder concrete blocks 13.0		....	1.22	1.25	0.33	0.214
8. Same as above, hollow spaces filled with cinders....13.0		....	1.32	1.16	0.233	0.169

The 1930 Guide published by the *American Society of Heating and Ventilating Engineers,* quotes heat conductance values for concrete ranging from 4.84 to 8.0 Btus per inch of thickness. These figures cover densities ranging from 103.6 to 145 pounds per cubic foot. In the table above the nearest approach to these densities is 93.5 pounds per cubic foot for crushed brick concrete covered with lime plaster. The conductance shown in 0.64 Btus for a thickness of 6.7 inches, equivalent to approximately 4.3

It is always interesting to see comparisons made showing tests of heat flow with the comparisons reduced to units with which we are familiar, and to see further the impressions which an article of this type has made on a man with the experience of Professor Peebles.—E. C. Lloyd, Armstrong Cork & Insulation Company.

So far as the writer can determine, the results obtained by these two engineers are more or less confirmatory of the thermal constants which we are using in this country for similar walls and materials, and should add to our confidence in similar values given in the 1930 Guide of the American Society of Heating and Ventilating Engineers.—A. C. Willard.

Btus per inch of thickness. The agreement here, taking into account the discrepancy in density, is fairly good.

The Guide already quoted gives an average value of 1.34 for the inside surface factor K_1. The *average* value given above is 1.44, while for K_2 (the outside surface factor) it is 1.13. These factors are for normal air circulation only, unaffected by wind. It will be noted that these surface factors agree reasonably well with American practice. The effect of wind is to increase greatly the outside surface factor, many American engineers employing a factor three times the 1.34 used as the inside factor.

Frame Construction

In Table 2 below we give the results obtained on various forms of frame construction.

Table 2

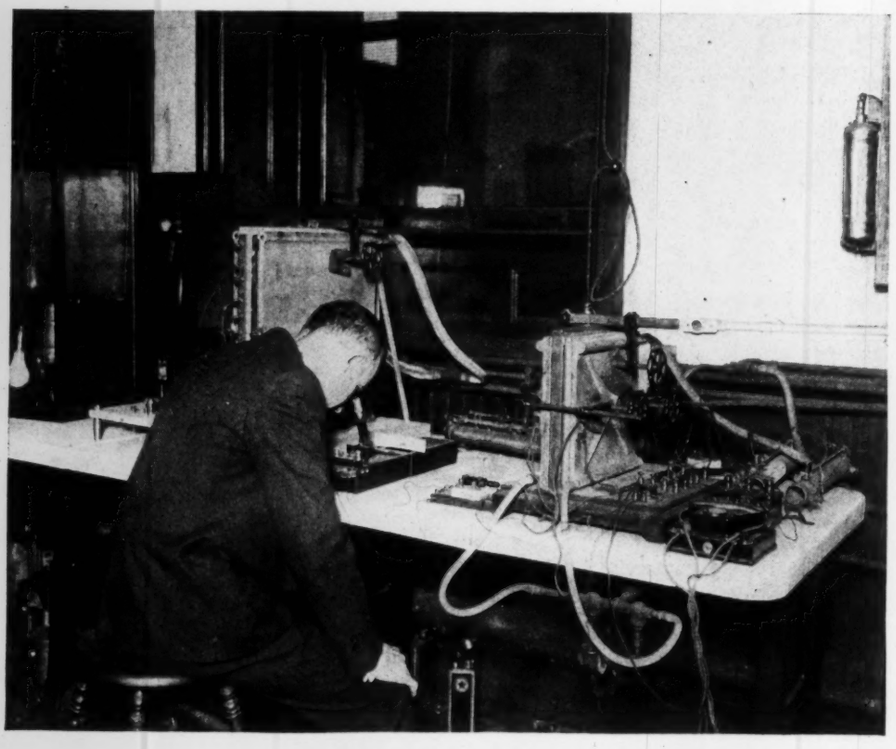
Heat Transmission of Frame Walls

Nature of Construction	t	K_1	K_2	C_u	U
1. Wood studding covered on both sides with veneer and with matched boards outside	7.5	3.10	1.37	0.245	0.194
2. Same as above, filled with blocks of pressed moss	7.5	1.47	0.82	0.075	0.065
3. Three panels of T & G boards, impregnated paper and shingles, containing narrow air space	5.5	1.08	0.72	0.169	0.122
4. Same as above, one side covered with Finnial paper board	5.5	1.10	0.92	0.118	0.098
5. Paper board, air space paper, and three thicknesses wood planking	5.5	0.98	0.78	0.153	0.112
6. Same as above after 8 years use	5.5	1.02	0.76	0.132	0.102
7. Triple thickness of wood, filled with wood shavings; two thicknesses paper	4.7	1.28	0.90	0.159	0.122
8. Same as above, covered with asbestos cement	5.9	1.45	0.80	0.128	0.104

None of the constructions listed above corresponds exactly with what is known in this country as "standard frame." The only one even approximating such a construction is number one in the above table, with a transmission co-efficient of 0.194 Btus. Our standard frame is usually given at 0.22 to 0.26 Btus. The other constructions considered are rather special and not directly comparable with prevailing practice in this country. However, the engineer familiar with such work will note that the results conform closely with what one would expect for the constructions considered.

Brick Walls

Table 3 below gives the results of tests on brick walls.



THE WRITER OF THIS ARTICLE IN HIS LABORATORY AT ARMOUR INSTITUTE, CHICAGO, MEASURING HEAT FLOW THROUGH THERMAL INSULATORS BY MEANS OF THE GUARDED HOT PLATE CONDUCTOMETER. TEMPERATURES ARE MEASURED BY SMALL THERMOCOUPLES CONNECTED TO A REFLECTING GALVANOMETER. THE OPERATOR IS SHOWN TAKING GALVANOMETER READINGS. THIS METHOD MAKES IT POSSIBLE TO READ THE TEMPERATURE TO ONE-TENTH OF ONE DEGREE

Table 3

Heat Transmission of Brick Walls

Nature of Construction	*t*	*d*	K_1	K_2	C_u	*U*
1. Brick, finished on both sides with lime plaster	18.8	107.0	1.39	1.19	0.271	0.192
2. Same as above, but 13-in. thick	13.0	107.0	1.59	1.28	0.378	0.247
3. Same as No. 1 above, but with different brick	18.8	112.0	1.51	1.36	0.247	0.183
4. Brick, finished on both sides with lime plaster	15.7	112.0	1.38	1.06	0.294	0.198
5. Brick, finished on both sides with lime plaster	11.0	112.0	1.45	1.18	0.474	0.274
6. Brick, finished on both sides with lime plaster, with 6-in. hollow space	14.5	.....	1.37	1.22	0.367	0.231
7. Same as above, hollow space filled with coke slag	14.5	.....	1.45	0.96	0.133	0.108
8. Same as above, hollow space filled with granulated charcoal	14.5	.....	1.59	1.00	0.100	0.086
9. Hollow tile, finished on both sides with lime plaster	12.6	.....	1.51	1.37	0.363	0.241
10. Same as above, hollow space filled with bark	12.6	.....	1.67	0.98	0.145	0.118

In the above table the first five samples are solid brick, ranging in thickness from 11 inches to 18.8 inches. We may calculate the unit conductance of the brick by multiplying the total conductance C_u by the thickness in inches thus:

Sample	*t*	C_u	*C*
1	18.8	0.271	5.1
2	13.0	0.378	4.9
3	18.8	0.247	4.65
4	15.7	0.294	4.6
5	11.0	0.474	5.2

Average value $C = 4.9$

The Guide of the *American Society of Heating and Ventilating Engineers* uses a value of five for the conductance of brick work, which agrees fairly well with the above average. In general, our brick work has a somewhat higher density than is shown in Table 3 for the Swedish product, so that our value of *C* would properly be slightly higher than theirs.

Tests on Windows

Table 4 below gives the results obtained from the tests on windows.

Table 4

Heat Transmission of Windows

Description	*U*
1. Single pane, 0.072-in. thick, in wood sash—	
Natural air circulation	0.78
Forced air circulation	1.26
2. Double pane in wood sash, glass 0.072-in. thick—	
Natural air circulation	0.57
Forced air circulation	0.84
3. Double pane in iron sash, natural air circulation	0.59
4. Triple panes in wood sash—	
Natural air circulation	0.47
Forced air circulation	0.63
5. Double windows of single panes, glasses—1⅜-in. apart	0.42
6. Same as above, glasses—4-in. apart	0.39

Among American engineers it is quite common practice to use 1.0 Btu per hour as the heat transmission of single thickness window glass, and 0.5 Btu for double thickness. These figures are for actual working conditions, involving more or less wind effect on the outside surface. The data in Table 4 show results somewhat higher than these, especially when forced air circulation is used. It is not unlikely that our figures on heat transmission through glass are a bit too low, in which case further research should be undertaken. However, in defense of American practice it must be recalled that fairly liberal allowances are nearly always made for windage effects, particularly on the sides of the building exposed to the prevailing winds. This allowance is often as high as 20 per cent of the accepted heat transmission factor, so that it is entirely probable that our practice, insofar as windows at least are concerned, conforms substantially with the results obtained in the Swedish investigations.

Two Tests on Corkboard

This report by Kreuger and Eriksson contains only two tests on corkboard, but they are interesting as affording a comparison with the factors commonly employed in this country. The results are shown in Table 5 below.

Table 5

Heat Transmission of Corkboard

	t	*d*	K_1	K_2	C_u	*C*	*U*
1	1.14	11.8	1.28	1.43	0.338	0.385	0.222
2	1.97	8.1	1.02	0.70	0.135	0.266	0.102

Perhaps the most interesting item in the above data is the unit conductance *C*. The spread from 0.266 to 0.385 is rather wide, even when the difference in density is taken into account. Tests on corkboard conducted by the U. S. Bureau of Standards give unit conductances ranging from 0.27 to 0.34, corresponding to densities varying from 7.0 to 14.0 pounds per cubic foot. Another point worthy of notice in the above results is the rather wide variations in the surface factors, K_1 and K_2. It is practically impossible to maintain surface conditions, particularly as regards air movements, even reasonably free from change, and this accounts for the discrepancies noted in the surface factors.

For homogeneous materials like corkboard, American practice prefers the guarded hot-plate method of test, in which surface effects are practically eliminated. The data quoted above from the Bureau of Standards were obtained by this method and are doubtless more accurate than those obtained in the investigation under consideration. On the other hand, when non-homogeneous structures, particularly types of building construction are to be considered, some form of hot-box or hot room seems preferable. In this field the results of the Swedish investigation are interesting and instructive, and in very good agreement with work done in this country using our guarded hot-box method.

People absorbed in what they are doing do not often stop to think of the danger and often do very foolish things thoughtlessly if there are no provisions to guard against them. This should be borne in mind when installing mechanical equipment.

The Iron and Steel Family

By Bryan T. McMinn*

The subject of metallography is becoming of more and more interest to lay engineers, contractors and others concerned with the use of iron and steel, as indicated by numerous references in technical and trade journals and in advertisements.

IRONS and steels differ from one another remarkably little in chemical composition. The softest and weakest cast iron differs from the hardest and strongest steel by only about two per cent of carbon. And the most brittle high-strength steel differs from highly ductile and workable wrought iron by less than that. Wrought steel is used for valves and fittings for extremely high temperatures and pressures, while the chemically identical but physically very different cast steel can be used for lower pressures and temperatures.

Because of the great similarity of chemical composition and the great difference in properties and behavior of the many products of this family, it is not surprising that there is considerable confusion in the mind of the

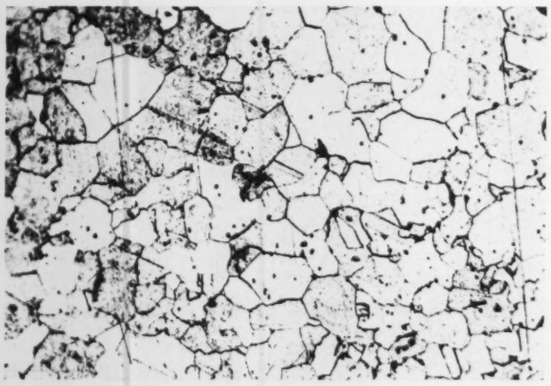


FIG. 1—WROUGHT IRON, POLISHED AND ETCHED CROSS SECTION OF BAR. MAGNIFICATION, 100 TIMES

average user of these materials regarding their characteristics. Many of the differences observed between members of the iron and steel family are wholly physical, and the differences due to chemical changes are indexed by physical changes, so the study of the physical make-up of these metals is very informative. This study is pursued largely with the aid of the microscope and is known as the science of metallography. Metallography provides an excellent avenue of approach by which one concerned with the use of irons and steels may obtain a working knowledge of their properties and utility.

Wrought Iron and Steel

Wrought iron is nominally chemically pure iron, although commercially it contains slag up to a few per cent, and sometimes a small amount of the carbon-bearing constituent of steel. If a piece of wrought iron is suitably polished and etched and examined under the microscope, it will exhibit the structure shown in Fig. 1. The network of lines enclose iron grains, each of which is made up of many cubic crystals so minute as to be indistinguishable even at the highest magnification obtainable. The grains of iron are irregular in shape and vary considerably in size, though not over wide limits.

Most commercial wrought iron is a product of rolling, and the slag, which was in roughly spherical globules in the iron as it came from the furnace, is drawn out into threads in the product. Fig. 1 is of a cross-section (right angles to the direction of rolling) of a bar, in which the slag threads show as dots or round blotches. Fig. 2 is of a longitudinal section (parallel to the direction of rolling), in which the threads of slag show as jagged lines. The fibrous appearance of a fracture of wrought iron is wholly due to this thread-like distribution of the slag,—the iron grains are in no sense fibrous. Of the different constituents of steel, the iron grain is the most ductile, from which it follows that wrought iron, being made up almost exclusively of that grain, is the most highly ductile of the iron-carbon alloys.

Theory of Corrosion from Difference in Electrolytic Potentials

Wrought iron is widely used for pipe, largely because of its resistance to corrosion. The usual explanation of this resistance is on the basis of purity, meaning the

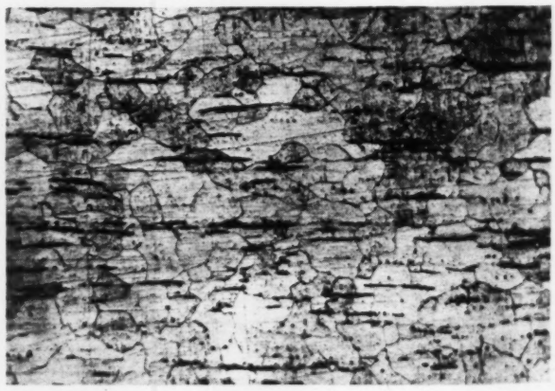


FIG. 2—WROUGHT IRON POLISHED AND ETCHED, LONGITUDINAL SECTION OF BAR. MAGNIFICATION, 100

* Assistant Professor of Mechanical Engineering, University of Washington.

FIG. 3—SHOWING THE FINE LAMINATED STRUCTURE OF ALTERNATE PLATES OF CEMENTITE AND IRON IN STEEL. MAGNIFICATION, 100

presence of but one metallic constituent. When there are two or more metallic constituents having different electrolytic potentials, it is supposed that local pairs of them act as electrolytic cells in the presence of moisture and suffer electrolytic decomposition. Iron nominally has but one metallic constituent, hence local electrolytic cells cannot exist.

The Characteristics of Steel

Steel is essentially an alloy of iron with not more than two per cent carbon with minor amounts of impurities usually present, and sometimes third and fourth alloying constituents, such as tungsten, chromium, copper, and nickel. The carbon in steel never appears as such, but is chemically combined with enough of the iron to make the compound ferric-carbide, or cementite, which mechanically mixes with the rest of the iron to make steel.

Ordinary steel, then, is a mixture of cementite and iron, but this mixture is very peculiar, in that the two materials will mix in finely-divided particles in only one ratio, of 13 per cent cementite and 87 per cent iron. These fine particles are disk-like in shape, and arrange themselves in a definite form, a very fine laminated structure of alternate plates of cementite and iron. This very intimate mixture is known as an eutectoid, and is shown in Fig. 3. To produce this type of mixture (13 per cent cementite and 87 per cent iron) requires 0.85

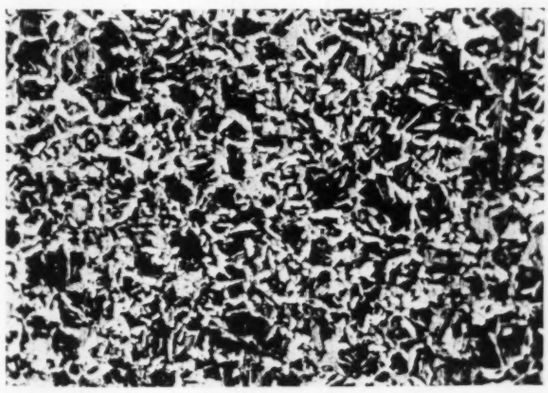


FIG. 4—A 45 PER CENT CARBON STEEL. THE LIGHT AREAS ARE IRON GRAINS AND THE DARK, PEARLITE OR EUTECTOID. MAGNIFICATION, 100

The various apparatuses and equipment used in heating, piping and air conditioning are almost without exception made of metal. Metal and metal alloys vary greatly as to their characteristics; resistance to corrosion from liquids and gases, torsion and tensile strength, hardness, flexibility, etc. Special metals and alloys are selected for air washers, boilers, vats, steam traps, valve seats and discs, valve stems, and piping for the myriad devices and parts that are used in these fields.

Maintenance engineers demand special metal in pipes for acetylene gas lines, for hot oil lines and for conducting many of the liquids and gases that are incident to manufacturing processes; pickling liquids in which metals are immersed prior to bending, drain connections for acid vats, etc.

Special alloys recently have been produced alleged to maintain original strength at super-temperatures and which are said to be valuable for super-pressure boilers and other high pressure vessels, new alloys that have great strength in proportion to weight, alloys that have a special proclivity for transmitting heat, etc.

Each line of these devices had its start in consideration of the metals to be used. Such study is not only essential at the beginning but also at the end and throughout the life of every piece of mechanical equipment used in connection with the application of heat, liquids and gases.

Prof. McMinn's article involves considerations that permeate every root and branch of heating, piping and air conditioning.

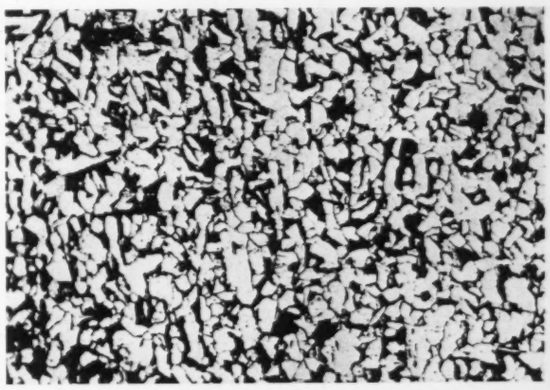


FIG. 5—A 25 PER CENT CARBON STEEL, APPROXIMATELY ONE-THIRD OF THE AREA IS PEARLITE. MAGNIFICATION, 100

per cent carbon and the remainder iron (discounting impurities), and a steel of that composition is known as an eutectoid steel or a pearlitic steel,—pearlitic, because the very fine parallel plates of cementite and iron give a scintillant appearance to the prepared surface, very much like mother of pearl.

This intimate mixture of these constituents produces the highest strength of any possible of them, and a plain-carbon (not alloy) steel of 0.85 per cent carbon is the strongest that can be had in the annealed or normalized state.

The intimate mixture characterizing the eutectoid occurs only when the composition is as above. Steels of other carbon content consist of the intimate mixture so far as the constituents are present in the right ratio, with that which is left over forming a coarse mixture with the eutectoid.

Fig. 4 is of a 0.45 per cent carbon steel, the light areas being iron grains, and the dark, pearlite or eutectoid (the laminations do not appear here because of their extreme fineness and the relatively low magnification). The relative area occupied by the pearlite is a measure of the carbon content. Had there been enough carbon to make the eutectoid mixture all over the section, the carbon percentage would be 0.85. Fig. 4 is approxi-

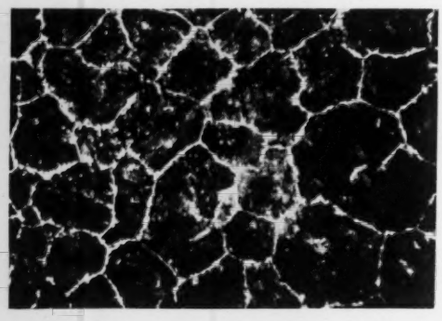


Fig. 6—A 1.20 Per Cent Carbon Steel. The Light Areas Are Cementite and the Dark Areas Pearlite. Magnification, 200

mately half pearlite, so its carbon content is 0.45 per cent, very nearly. Fig. 5 is of a .25 per cent-carbon steel, and approximately one-third of the area is pearlite.

Fig. 6 is of a 1.20 per cent-carbon steel. The formation of the eutectoid mixture in such a steel leaves cementite as the excess constituent, to be coarsely mixed with the pearlite to make the whole. In Fig. 6 the light areas are cementite, while the dark areas are pearlite. Determining the carbon content of plain steels by microscopic examination for the amount of pearlite is entirely practical, particularly in low-carbon steels, and is a method widely used.

Pearlite, because of the extreme intimacy of the mixture making it, has distinctive and consistent physical properties, neither those of iron nor those of cementite. Its ultimate tensile strength is 115,000 lb. per sq. in.,

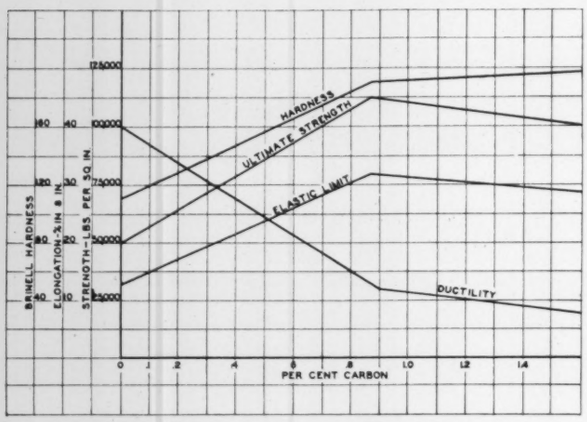


Fig. 7—Physical Properties of Steel as Measured by Carbon Contents

its elongation twelve per cent in eight inches, and its hardness nearly double that of wrought iron.

Physical Properties of Steel Measured by Carbon Contents

The fact that plain annealed steels not of eutectoid composition are relatively gross mixtures of pearlite and iron or pearlite and cementite, means that the physical properties will be proportional to the relative amounts of the constituents, which are readily measured in terms of the carbon contents.

This statement is proved by the curves of Fig. 7, which were plotted from test data. Thus a steel with half enough carbon to make it eutectoid is half pearlite and half iron, and has a strength half way between those of pearlite and iron, with other properties in proportion. With carbon above the percentage required for the eutectoid composition, a steel is a mixture of pearlite and cementite, and its properties are means between those of pearlite and cementite.

Because steel is thoroughly molten in the process of manufacture, only minute particles of slag will remain in the ingot to be drawn out into threads by the rolling or forging, so a steel does not show the coarse threads of slag that wrought iron does. The slag in a finished

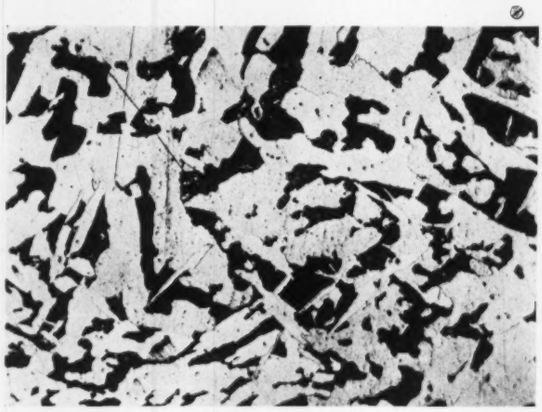


Fig. 8—Cast Steel of Identical Composition to the Wrought Steel in Fig. 4. Magnification, 100

piece of steel is in very fine threads and uniformly distributed. Low grade steel has enough slag in it to produce a slightly fibrous fracture, not nearly as fibrous as wrought iron, however, while a high grade steel has only traces of slag.

Characteristics of Cast Steel

Metals cooled slowly and without disturbance from the solidification temperature tend to form large, erratic grains. The essential difference between cast steel and wrought (rolled or forged) steel is that the casting is slowly cooled, and undisturbed during the process, while rolled or forged steel is mechanically worked and thus violently disturbed while cooling. This working breaks up the large grains as fast as they form, giving a fine grain to the product. Tests show that fine grain size is highly desirable, being conducive to high strength and shock resistance. The principal advantage of wrought steel over cast is in this matter of grain size. Steel forgings are used largely in critical places, such as for valves and piping accessories for very high pressures and

temperatures, because of the consistency of properties guaranteed by the fine grain.

Fig. 8 shows a cast steel of identical chemical composition to the wrought steel of Fig. 4. The microstructure is of pearlite and iron, but very much coarser and more erratic than Fig. 4. The steel of Fig. 8 showed in a test but 60 per cent of the strength and 30 per cent of the ductility of that of Fig. 4, the difference being wholly due to the coarse structure. Cast steel can be remarkably improved by careful annealing.

Fig. 9 shows the result of annealing the cast steel of Fig. 8, the new structure approaching that of rolled steel for fineness and consistency. The improvement in the strength and ductility, which largely govern the shock-resistance, due to the annealing of cast steel, is very marked.

Cast steel is a desirable material for valve bodies and certain fittings for moderately high pressures and temperatures because of its ready castability in the complicated shapes required, combined with strength, ductility and consistency.

Cold-Working

The rolling or forging heretofore referred to is "hot-working," working done above the critical temperature, or recalescence point (approximately a medium red heat). Rolling or forging, or forming of any kind,

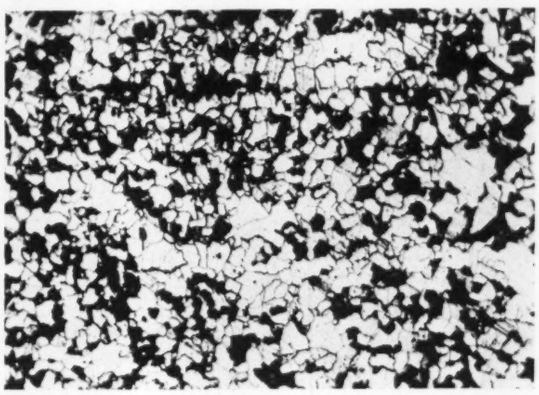


Fig. 9—Showing Results of Annealing the Cast Steel Shown in Fig. 8. Magnification, 100

done below that temperature is "cold-working," and has an entirely different effect upon the material. Hot-working breaks up grains, forming perfect new ones, while cold-working merely deforms the grains. This deformation strengthens the material wherever it occurs (cold-rolling, for instance, is a "skin-effect") to a considerable degree, but also embrittles it. When the embrittling is of minor importance, as in shafting, the cold-working is desirable, as it produces cheaply, a high-strength material.

The embrittling due to cold-working may be disastrous in some cases, for instance, the cold-straightening of a bent automobile steering-arm. The repetition of this process may make the arm so brittle that a minor shock load may cause it to fail.

Fig. 10 shows the effect of cold-rolling on the microstructure of a steel originally the duplicate of Fig. 5. The effects of repeated cold-working are cumulative,—the repeated bending of a piece of sheet metal in an attempt to break it is an example; it finally breaks after being bent through a much smaller angle than was the first, due to brittleness. The changes in structure and

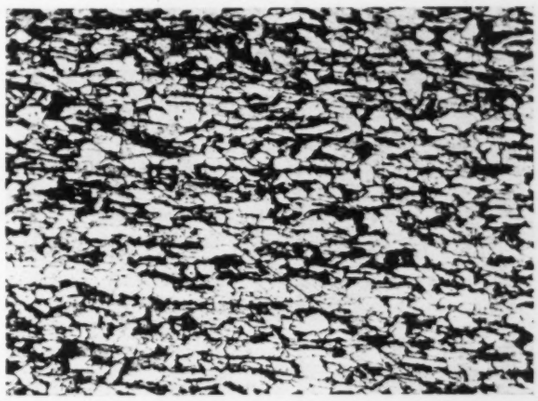


Fig. 10—Showing the Effect of Cold-Rolling of the Steel Shown in Fig. 5. Magnification, 100

properties caused by cold-working can be removed by proper annealing.

Importance of Carbon in Steel

Carbon in steel is of extreme importance for two reasons; first, the direct influence in strength, as evidenced by the curves of Fig. 7; and second, the amenability to heat-treatment which it bestows. Wrought iron cannot be hardened or otherwise changed appreciably by heat-treatment, but as carbon is added the alloy becomes responsive, and when the carbon content reaches 0.85 per cent, the response is remarkable—such a steel may have its properties varied over a wide range almost at will through varying the heat-treatment.

Cast Iron, Gray and White

Cast iron is the name given to the iron-carbon alloy when the carbon is above two per cent. The carbon in commercial cast iron varies considerably, but 4.3 per cent is considered desirable for most purposes. The microstructure of cast iron is very complex and variable and the properties are therefore relatively erratic. Some of the variations in microstructure and properties are controllable, others are not. The carbon in cast iron may be free, plain graphite, or chemically combined as cementite, which, in turn, heterogeneously may be mixed with the other constituents or intimately may be combined in the form of pearlite. The two principal factors governing these possibilities are the rate of cooling and the silicon content.

When cast iron is allowed to cool slowly, as in a sand mold, the carbon, which was in the form of cementite on solidification, gradually breaks loose from the compound and appears as free carbon, or graphite, in the resulting casting. By volume such a casting is approximately ten per cent graphite. The black graphite mixed with the white iron gives the characteristic gray color to a fracture, giving rise to the name, gray cast iron.

If cast iron is cooled very rapidly from the solidification temperature, as by casting in a metal mold, the carbon remains in the chemically combined form of cementite, and the cast iron resulting is by volume approximately half cementite and half iron. Both of these are metallically white, and the fracture of an iron so made

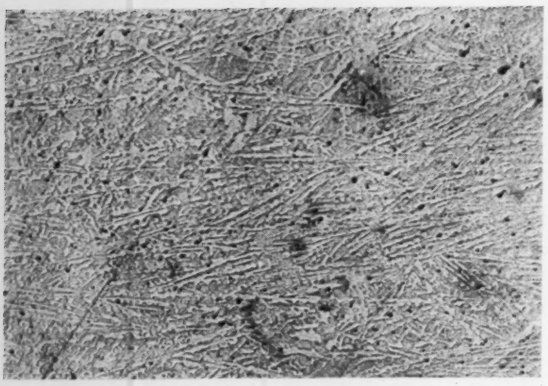


FIG. 11—WHITE CAST IRON. MAGNIFICATION, 100

up is white—hence the name, white cast iron. Cementite is hard, so hard that it can be shaped only by grinding, and then only with great difficulty, so the use of white cast iron is usually limited to producing hard wearing surfaces on car wheels, anvil tops, rail frogs, plow shares, and similar parts, where they require a minimum of shaping after casting. Where only a part of a casting is put through an accelerated cooling process, the white iron so produced is known as chilled iron. Fig. 11 is of white cast iron. The brilliantly white, needle-like grains are cementite, while the slightly darker grains are iron.

Silicon in cast iron has the same effect as time, so far as the state of the carbon is concerned. The carbon in a high-silicon iron tends to free itself and make the product gray cast iron, so where extreme softness is desired a cast iron high in silicon is used. Correspondingly, white cast iron is usually low in silicon. Silicon makes cast iron more "fluid," in foundry parlance, through lowering its solidification temperature and permitting it to fill complicated molds without "cold-shutting."

In ordinary foundry practice, the control of the state of the carbon is often poor, and commercial gray iron may have a considerable portion of its carbon combined. In a large casting having both heavy and light sections, the heavy sections will cool slowly, permitting graphitic carbon to form, making those sections soft, weak, and brittle, while the thin sections will cool rapidly, have more combined carbon, and hence be harder, stronger, and more difficult to machine.

Commercially, the terms white and gray iron are relative. If a fracture of a commercial cast iron is gray and the casting is relatively soft and easily machined, it is called gray iron, even though a third of its carbon is combined. A commercial gray iron has these microscopic constituents readily distinguishable: iron, carbon, cementite, pearlite, and slag. Cast irons of phosphoretic pig have other constituents not of interest here.

FIG. 12—A GRAY CAST IRON SHOWING CARBON PLATES IN THE FORM OF BLACK STREAKS. MAGNIFICATION, 100

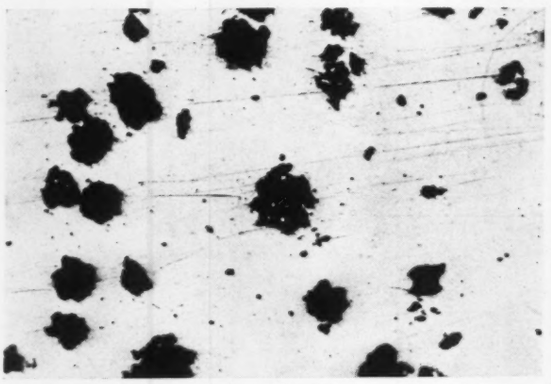


FIG. 13—MICROGRAPH OF METAL IN A MALLEABLE IRON PIPE FITTING. MAGNIFICATION, 100

The major point of interest in gray iron under the microscope is the mode of occurrence of the carbon. A gray cast iron is shown in Fig. 12, in which the black streaks are carbon plates or disks, while the white background consists of iron, pearlite, and cementite (suitable preparation would make these distinguishable, one from another). While the volume of carbon is perhaps but ten per cent of the whole, the thin plates in which it occurs break up the continuity of the constituents responsible for the strength and ductility. This accounts for the very low strength and great brittleness of gray cast iron. The iron and pearlite in cast iron are just as strong and shock-resisting as they are when in a high-strength steel, but they do not have a chance to develop those characteristics because of the effect of the carbon.

Gray cast iron is sometimes troublesome when used for engine and pump cylinders, valve bodies, separator bowls, and the like, because of its porosity under high pressures. This porosity is due to some extent to the loosely-knit structure resulting from the mode of occurrence of the carbon.

Malleablizing is a process for producing a material chemically identical to gray cast iron, with its advantages of cheapness and castability in complicated molds, but with the carbon distributed in a less harmful way. A malleable casting is first cast as white cast iron, and then annealed. The annealing frees the carbon from the cementite of the white iron, but instead of leaving it in the disk-like form as in gray iron, it leaves it in roughly spherical globules known as "temper-carbon," which interrupt the continuity of the metal structure much less. Fig. 13 is of a malleable iron pipe fitting. The light areas are iron, and the black, carbon. Compare Fig. 13 with Fig. 12, which is of very nearly the same chemical composition, to discover the advantage of malleablizing. It will be seen that malleable cast iron is in effect wrought iron with carbon globlues scattered through it. It is, of course, common knowledge, that the properties of malleable iron are much nearer those of wrought iron than those of ordinary cast iron.

Conditioned Air for Glue?

IN manufacturing glue, the final operation is the removal of water. This is true whether a liquid or dry product is desired.

Let us assume that the exposed surface is half water and half glue. As the water in this surface mixture is vaporized, it becomes increasingly difficult for the water below the surface to push up to the surface. This is due to the peculiar characteristics of the glue itself. It is therefore evident that the rate of drying can be hastened by spreading out the glue mixture or by stirring. The first named expedient is not always practical, as it is limited by the design of the drying equipment and by space requirements.

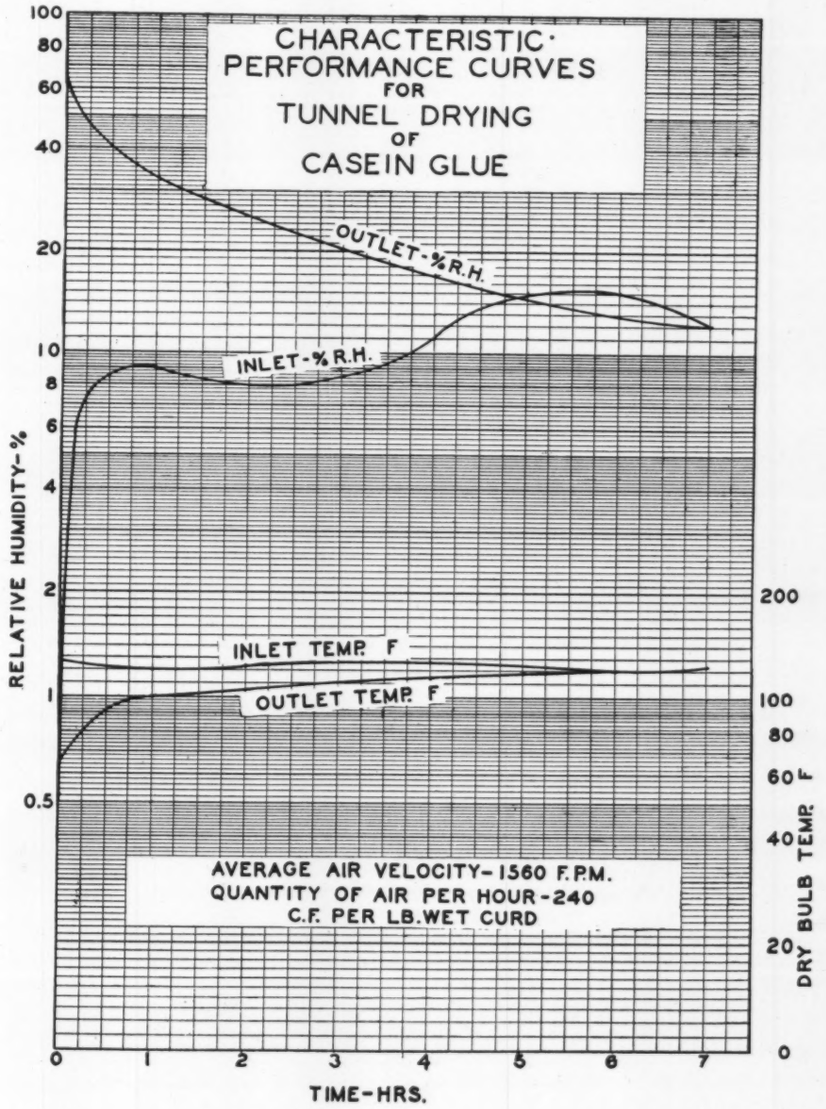
Vapor Pressure

The effect of the relative vapor pressure, or the relative humidity (which is the same thing), is interesting. Saturation of the air, or 100 per cent relative humidity, will effectively stop all vaporization of the water out of the glue mixture. As the relative humidity is lowered, the water vaporized from the glue increases. This is the reason liquid glue gradually dries out when exposed to air, for the relative humidity of the atmosphere is seldom as high as 100 per cent. Furthermore, air motion has a marked effect on the rate of drying.

Thus it becomes evident that, no matter what the condition of the glue may be, outside of absolutely dry, the amount of surface exposed, the amount of stirring (if any), the relative humidity of the surrounding air and the rate of air motion are all factors of great importance in its drying. It is to be expected, naturally, that another factor is temperature. This latter factor is not as vital as the first four, as far as drying glue is concerned, since it may not be varied beyond fixed limits without damage to the glue.

Performance Curves for Casein Glue Curds

A set of characteristic performance curves for the drying of casein glue curds are given in the chart. The drier is of the tunnel type. The quantity of curd and of air moved per hour has been held constant. Here temperature increase at the outlet is used to lower the outlet relative humidity gradually. The inlet temperature is held constant and the inlet relative humidity gradually increases until it is practically constant with the outlet. When both the temperatures and the relative humidities at the inlet and outlet are the same, respectively, the drying operation is finished for the wet curds. No conditioning of the air, prior to its introduction into the tunnel, is used.



It would be interesting to find out if the cost of conditioned air could be justified. If so, there can be no doubt that the rate of drying would not only be a constant throughout the operation but it would be increased so that much less than 7 hours would be required. To determine this point it would be necessary to run tests to determine what would be the best combination of temperature and relative humidity to employ. In the case plotted, a relative humidity of 12 per cent required a temperature of 124 F. As 12 per cent relative humidity would be expensive to provide, and as relative humidities above 40 per cent are less costly, it would be in order to use as high a temperature as possible and practicable and, if necessary, to increase the air motion.—*Malcolm Tomlinson.*

Cooling *with*

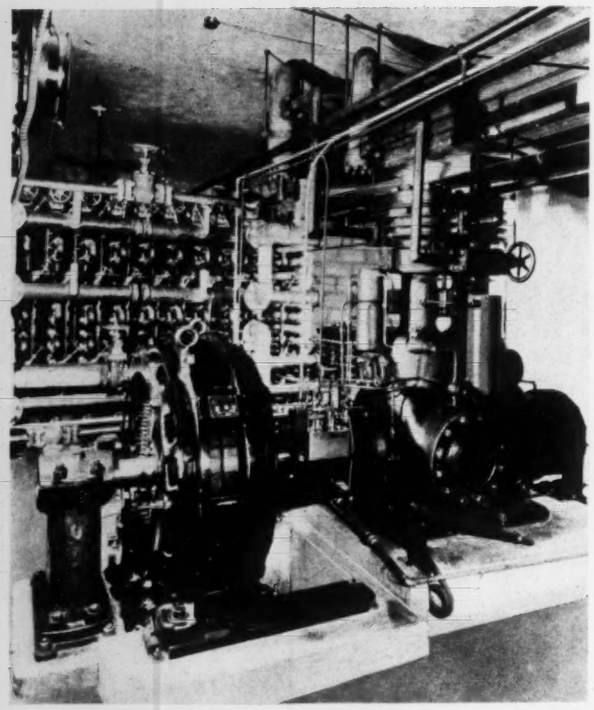


FIG. 1—ONE OF THE TWO LARGE CARBON DIOXIDE COMPRESSORS WHICH FURNISH REFRIGERATION FOR AIR CONDITIONING THE NEWARK THEATER, NEWARK, N. J. DOUBLE-PIPE CONDENSORS MAY BE SEEN IN THE BACKGROUND

COMFORTABLE indoor conditions are not provided by temperature alone. Humidity and air movement have much influence, and each application is a problem in itself. The theater, department store and office building differ from each other in the character of work done, kind of occupants, total number and number per unit of floor area.

In the theater the audience is still for a period ranging from three to four hours. Of course, people are coming and going at all times but their number is relatively small in proportion to the total number in the audience. People who are sitting still present an entirely different problem from those in a department store where they are moving about. Those in a theater should feel no draughts or cold air currents. Occupants of office buildings require special consideration. Here there are relatively few in number in each office. They must get a supply of conditioned air of proper temperature and humidity to suit their needs. Each office presents a different problem.

Laying Out the Equipment

In laying out nearly all air conditioning work, space for the equipment is at a premium. Often it has to be fitted in anywhere regardless of whether it is the ideal place or not. Often it is an afterthought or has to be applied to an existing building, in which case it presents a very difficult problem. Not only is space for the refrigerating apparatus frequently hard to find but to make room for installation of the air ducts is another problem.

Carbon Dioxide Compressors

There are several kinds of refrigerating apparatus which can be applied to air conditioning work. Some of them provide a greater refrigeration tonnage than others per area of floor space occupied. Fig. 1 shows an installation of two carbon dioxide compressors placed in a theater near New York City. These require a floor space of 300 sq. ft. and head room of 9 ft.-6 in. Each is the totally enclosed type and has no vertical shaft stuffing box. The stuffing box is of the horizontal rotating type. The compressor is equipped with an oil pump which keeps the bearing under oil pressure of from 400 to 500 pounds at all times. The stuffing box is kept cool by means of a gland in which gas from the suction line is allowed to expand.

Fig. 2 shows a cross section of a typical enclosed type carbon dioxide compressor. The thrust bearing takes the crank shaft thrust and equalizes the pressure between the crank case and the atmosphere. It operates at all times under oil pressure.

Each compressor is built with a starting by-pass and safety valve. This valve is of the spring type which blows at 1,500 pounds pressure and reseats when the pressure is relieved from 200 to 300 pounds.

In order to eliminate noise the carbon dioxide compressor and motor are often placed on foundations of cork. In other cases, the foundation is built in a pit which has been lined with cork.

Carbon Dioxide Condensers

One type of CO_2 condenser consists of an eight-inch double extra heavy pipe with seven 1½-in. pipes welded into the tube head. The water heads are of cast iron and divide the shell into several water passes. Fig. 3 shows a view of such a condenser. These can be arranged any number of pipes high depending on head room available. They can be placed on 18-in. horizontal centers. Each

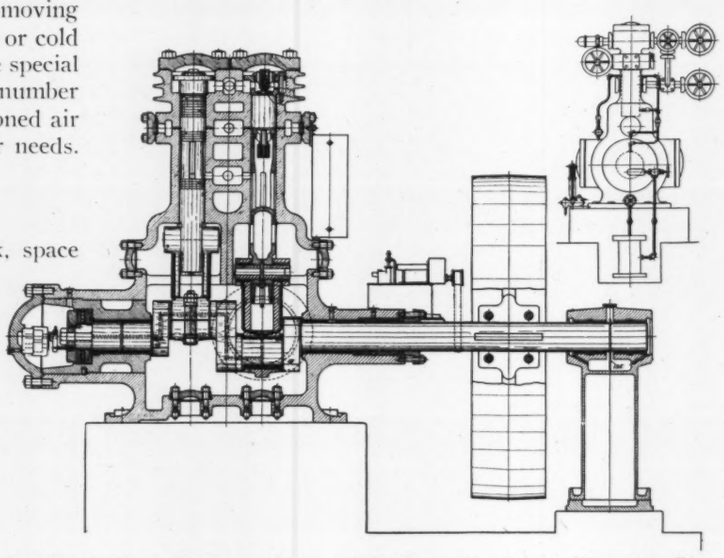


FIG. 2—A CROSS-SECTION VIEW OF AN ENCLOSED CARBON DIOXIDE COMPRESSOR

Carbon Dioxide

By A. N. Chandler*

shell can be arranged to take from 20 to 40 gallons of water per minute, depending upon the range of temperatures desired or work to be done. The water leaving the condenser is within a few degrees of the carbon dioxide liquid temperature off the condenser.

As an example, an installation requiring 350 tons refrigeration and using shell and tube condensers could be arranged in a floor space 7 ft. wide by 22 ft. long. Furthermore this space allows room for carbon dioxide and water headers. On this installation, the head room required would be 11 ft. 6 in.

Fig. 4 shows a typical carbon dioxide double pipe welded condenser. It is made up of 1¼-in. water pipes throughout. The four top sections are made up of 2½-in. extra heavy pipe and the remaining eight pipes of 2-in. extra heavy pipe. The 2½-in. and 2-in. pipes are welded to the 1¼-in. pipes at each end. The reason for the larger top section is to absorb the pulsation of the carbon dioxide gas from the compressor which causes a cushioning effect. The water is so arranged that the coolest water comes into contact with the coolest gas making the temperature of the carbon dioxide liquid off the condenser near the initial water temperature. Fig. 1 shows several stands of double pipe welded condensers.

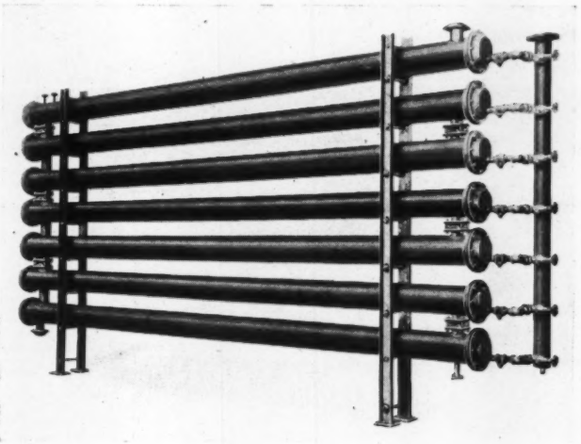


FIG. 3—MULTI-PASS SHELL-AND-TUBE CO_2 CONDENSOR, SHOWING STAND OF SEVEN 8-IN. SHELLS. THE VALVES ARE NOT ILLUSTRATED

Carbon Dioxide Oil Separators and Scale Traps

It is the general practice to supply each carbon dioxide installation with an oil separator and scale trap. These are inserted in the pipe lines between the compressor and condenser and in the suction line from evaporator. These vessels are either of welded construction or of cast steel, according to the standard of the manufacturer. The oil separator is always provided with an oil drain valve and with baffles which are perforated for catching and holding oil. The construction of the scale trap embodies a screen for catching any of the scale or dirt coming from the evaporating side. This trap must be made so that this screen can be cleaned thoroughly at intervals.

Carbon Dioxide Receiver

The next important feature in the refrigeration cycle is the carbon dioxide receiver. This is used to collect and store the liquid which has been condensed in the condenser. The ordinary practice is to provide the receiver with valves for the inlet, drain, and outlet connections. Each receiver should also be provided with a gage glass equipped with automatic shut-off valves in case of breakage of gage glass. A safety valve should also be furnished in case all the valves should close and the liquid grow warm, causing an increase in pressure. The size of the liquid receiver varies, of course, with the size of installation but it is good practice to have it sufficiently large to hold the major portion of the charge in the system.

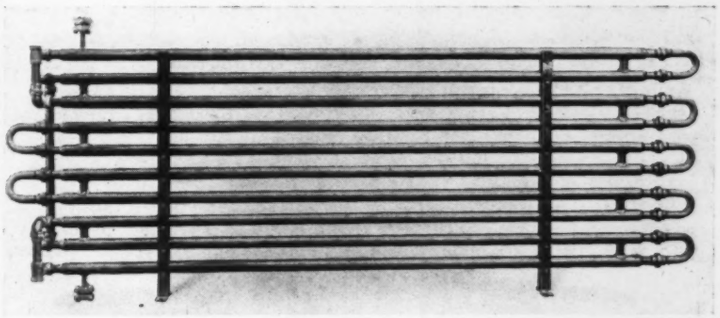


FIG. 4—A DOUBLE-PIPE CONDENSER FOR CARBON DIOXIDE. THIS IS OF WELDED CONSTRUCTION, HAS DOUBLE WATER CONNECTIONS, AND REMOVABLE RETURN BENDS

Carbon Dioxide Pipe Connections

Fig. 5 illustrates a typical carbon dioxide cycle. The pipe connections between parts are most important. General practice today seems to be to make a complete welded job of all the connections, making provision by means of bends for expansion. In carbon dioxide work all pipe connections should be bent, wherever possible, with a long bend. This gives the gas more of a chance to flow smoothly and eliminates the chance of vibration in the pipe lines. It must be remembered that in the discharge lines the gas attained a velocity of from 800 to 1,200 feet per minute at a pressure of from 1,000 to 1,400 pounds. Should this gas meet a right-angled bend, it would cause a severe shock which would pass to the hangers and be transmitted to the building.

In all large carbon dioxide pipe work, it is customary to anchor the lines to the floor and to provide cork pads so the shock will not be passed to the building. Elimination of all vibration is a very important factor in air conditioning work.

* Frick Company.

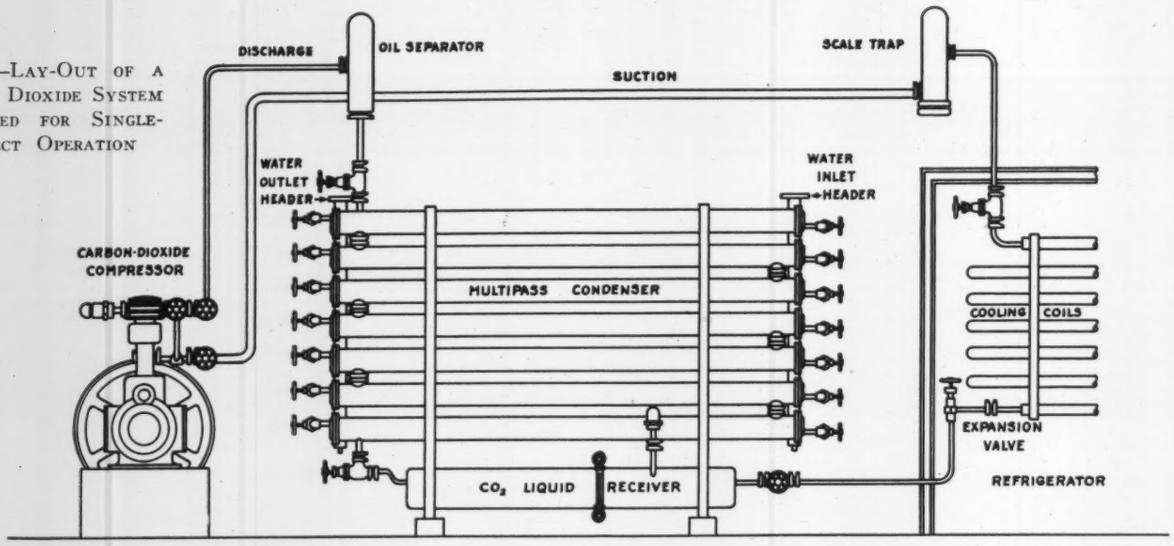


FIG. 5—LAY-OUT OF A CARBON DIOXIDE SYSTEM ARRANGED FOR SINGLE-EFFECT OPERATION

Water Cooling Apparatus

Air conditioning may require that air be dehumidified by passing it through the cool water sprays and filtering during summer months and used as a humidifier in winter months, at which time the air is preheated and humidified by the water and there tempered before delivery. Many air conditioning jobs are a combination of air conditioning and warm air heating systems. That is, in summer the air is cooled and dehumidified by passing through cooled water sprays and filtered; in winter it is preheated, humidified by water sprays, filtered and tempered.

Water used for spraying and dehumidifying the air may be cooled by several means, such as Baudelot cooler type coils, tank with submerged coils, or with special type coils and agitators.

The Baudelot cooler type construction entails a number of coils, standing vertical, over which water is distributed by means of sprinkler pipes or troughs. The coils are ordinarily galvanized and may have several pipes submerged in a tank. The water is then taken and pumped through nozzles in the dehumidifier. The Baudelot cooler type water cooler involves considerable space and requires an insulated room, which is rather expensive. It does, however, get a greater heat transfer than the plain tank submerged coils.

The tank and coil method of water cooling pertains to submerged coils in a tank. The tank is arranged with baffles to give the water velocity and thereby promote the heat transfer between the water and carbon dioxide gas in the pipes. The water is pumped from the tank to the dehumidifier. The discharge is taken from the tank from one end and returned to the other end.

The third method of water cooling referred to is by means of using special types of coils in a closed tank. This arrangement is adaptable to flooding with carbon dioxide liquid. High heat transfer is often secured with this method by means of special agitators developed for this purpose. By this method, the plant is not dependent on the water pumps for its agitation, and any particular dehumidifier can be operated independently of the other. The cooling units can be arranged so that the amount of water cooled can be varied. Cooling the water independent of the dehumidifier unit tends to give the plant flexibility and is adaptable to automatic humidity control.

Still another arrangement for cooling water is that of installing direct expansion carbon dioxide coils directly in the spray chamber of the dehumidifier. The carbon dioxide is expanded in the coils and the water is sprayed over them and thus cooled. The air is blown through the water and thus cooled and dehumidified at the same time. This arrangement results in a saving of floor space for the water cooling unit; the dehumidifier must be increased in size to accommodate the coils.

The method of distributing this cooled and dehumidified air depends on the type of building involved.

Gaskets for Refrigerating Piping

There are two main types of refrigerating machinery, the compression system which compresses a vapor by mechanical means, and the absorption system, where the vapor is compressed to liquefaction by heating a solution of aqua ammonia; hence, the compression machine has either liquefied gas or vapor, saturated or superheated, flowing through it, while in the absorption refrigerating machinery vapor is in some pipes and aqua ammonia in others.

The saturated and superheated vapors act in one way and the aqua ammonia a little differently because the aqua has water in it which has a rusting effect; furthermore, in the compression system machine oil is used for lubrication. The main difference in running the pipe is in the use of gaskets because oil often affects rubber. Hence, in compression machines, most gaskets should be of lead, preferably with a little antimony in them, while in the absorption machine rubber is used widely. If a lead gasket is tight a leak does not start, but when aqua ammonia once starts to run through, it tends to make a little groove which grows worse; hence, usual practice is to use rubber gaskets rather than lead in absorption machines, although lead is all right if made tight and kept tight. If pipes get hot the lead softens a little and vibration may shake it loose; therefore a good solid mixture should be provided and antimony is often used.—*Henry Torrance.*

Heating a Fruit Terminal
Presents Unusual Problems

By C. W. DeLand*

FIG. 1—THE CHICAGO PRODUCE TERMINAL AND FRUIT AUCTION, RECEIVING SEVENTY TO NINETY CAR-LOADS OF FRUIT EACH DAY

THE CHICAGO Produce Terminal and Fruit Auction is located at 27th St. and Ashland Ave., Chicago,where the Santa Fe Railway Co. has installed track and yard facilities, transformed an old freight house, 100 feet wide by 800 feet long, into a modern fruit receiving and distributing station, and has erected a modern office building, housing offices of the merchants and dealers, and provided other facilities necessary for the expeditious handling of the products daily coming into this terminal.

The purpose of this article is to tell something of the problems involved in the design and installation of the heating plant in this remodelled freight house.

Eleven Million Boxes of Fruit Per Year

The Chicago district absorbs daily hundreds of cars of fruit. From 70 to 90 car-loads of from 400 to 500 boxes each are received each day, excepting Sunday, by the Chicago Produce Terminal Co. and Fruit Auction. These are sold at daily auction sales to fruit merchants and other large lot buyers. These shipments include practically every variety of fruit except bananas, berries and melons. The fruit is carefully inspected during unloading and any that is frozen or spoiled is set aside and sold as "spoiled."

This would indicate a distribution into the Chicago area of about 40,000 to 50,000 boxes of fruit per day, from this one station—or over eleven million boxes per year at an average selling price of perhaps $6.00 or more per box. Yearly sales are in excess of sixty-six million dollars.

The sales are conducted in the "head-house," a four-story office and auction room section near the north end of the main building, in which is installed a separate direct radiation vacuum system which is cross-connected to the main heating plant. A restaurant, locker room and general toilet rooms are located on the main floor of this section.

The cars are set on tracks to permit unloading into the house from 2 to 8 o'clock a. m. Inspection by buyers goes on during the unloading period and the auction sales commence promptly at 9 o'clock. The entire day's shipment is sold to buyers before two p. m. and is removed by them before 5 o'clock the day of sale.

Frequent Opening of Freight Door and Cold Fruit Complicates Heating Problem

As previously stated, the building is 100 ft. wide and 800 ft. long with double tracks on each side. There are thirty-six 9 ft. × 15 ft. rolling steel doors on the east side and thirty-four on the west side of the building. The double tracks accommodate 60 freight cars on each side of building, and during the unloading time, 15 doors on each side are open irrespective of weather conditions. Heat losses were readily calculated for the structure as designed, but neither data nor experience offered means for calculating the heat losses through a series of open doors.

Another unknown quantity was the cooling effect of eighty or more car-loads of cold fruit unloaded in the building from refrigerator cars. Twenty-six thousand sq. ft. of direct radiation (or equivalent indirect radiation) was figured as necessary to compensate for the known losses (for a difference of 55 deg. between outside and inside temperature) and a minimum of 35 deg. at the floor line, and 12,500 sq. ft. added to compensate for the unknown losses. While the 12,500 sq. ft. additional was purely a guess, the results show that it was, at least, a good guess.

The indirect system was selected. Several lay-outs were studied for cost of installation, operating costs and convenience. The lay-out adopted divided the building into four zones of about equal area, each having two sets of apparatus and ducts, or a total of eight separate systems. Fig. 2 shows one of these systems. All apparatus, duct work, and steam and return mains are suspended from the roof construction.

One fan delivers air to the east wall of its zone

* Engineer, C. W. Johnson, Inc.

and the other to the west wall through sheet metal ducts, with a damper-controlled drop riser at each door, having an outlet fitting about 6 ft. above the floor, shaped to discharge the air to the floor and in toward the center of the building. The arrangement is such that the blast of heated air does not come into contact with the cold fruit. Each unit of fan and heater equipment is made up of a fan delivering about 9100 c.f.m. against 1¼ in. static pressure, direct connected to a 5 hp. 220 volt, 3 phase, 720 rpm motor equipped with automatic starter and push button switch, and two units of 2-row and two units of 3-row finned heaters, total 614 lin. ft. All air is recirculated. Steam is delivered to heaters at 5 to 20-lb. pressure, depending upon outside temperature. Combination float and thermo traps drain heaters into the vacuum return main.

A 50 ft. by 60-ft. boiler house with a 48 in. by 100-ft. high detached brick stack is located south of the main building.

The steam generating and pump equipment includes two down draft, portable, return tubular boilers built for 100 lb. working pressure (operating pressure 50 to 80 lb.); two vacuum pumps with automatic control; one 36 in. by 72 in. receiving tank with automatic feed pump governor; two 10 in. by 6 in. by 12 in. single boiler feed pumps together with soot blowers, stop check valves, reducing pressure valves, etc.

During the winter of 1928-1929 heating season, 175 tons of Illinois coal were used. Steam is maintained for 24 hours per day throughout the heating season; in mild weather only one boiler is operated. Steam and return mains are covered with 85 per cent magnesia.

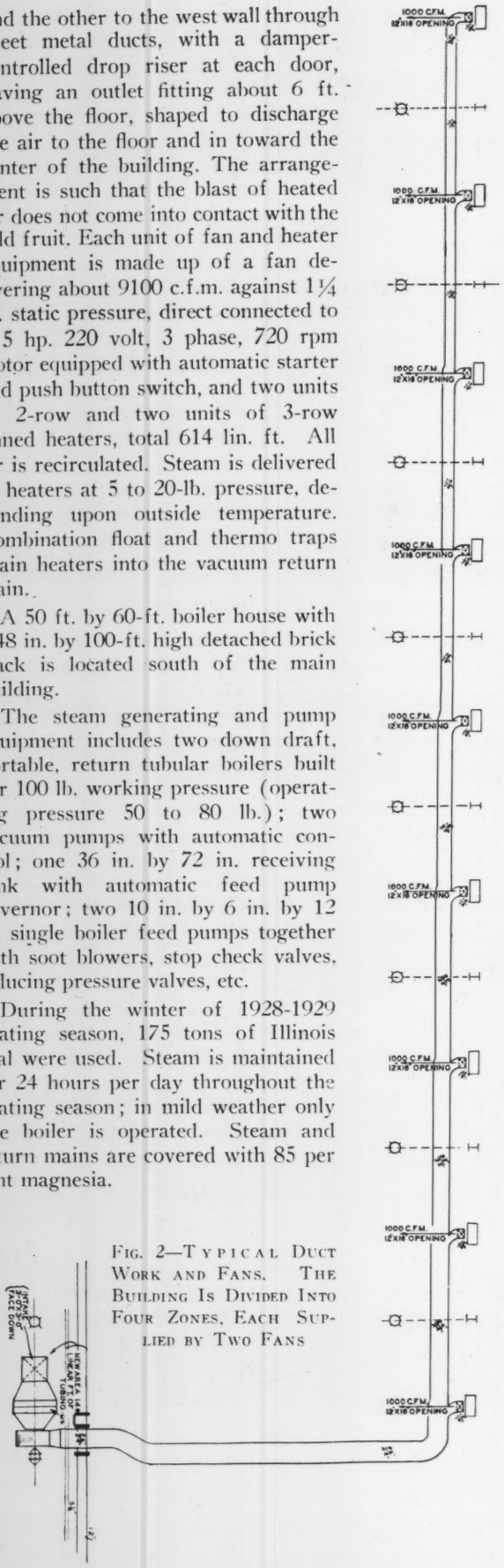


FIG. 2—TYPICAL DUCT WORK AND FANS. THE BUILDING IS DIVIDED INTO FOUR ZONES, EACH SUPPLIED BY TWO FANS

Water Logged Lines

The heating plant was completed and house placed in service early in November. The boilers were operated at 80-lb. steam pressure and reduced for heating lines to 5 lb., and the vacuum pump governors set to maintain 8 in. vacuum at the return pump. The system worked very satisfactorily under these conditions. A test at 20 lb. steam pressure, however, was not satisfactory because of loss of vacuum in return lines, and the consequent water logging and air binding of heaters beyond fan unit No. 2. The temperatures in the north sections of the house dropped 3 to 6 degrees. The returns were very hot, indicating, in the consulting engineer's opinion, leakage of steam through traps into return lines. Vacuum gage indicated 0 in. However, a careful check up and tests showed all steam traps tight, and the vacuum pump in good order.

This test was followed by another with steam at 7 lb. pressure; under this condition the vacuum rose to 7 in. with no change in control setting. All radiation filled with steam, there was no evidence of water logging or trapped air in the system and the temperature in the building was entirely satisfactory. At 4 lb. pressure operation seemed even better.

The operating engineer in charge was instructed to carry not more than 7 lb. steam pressure on heating lines unless extremely cold weather should make necessary an increase in steam temperature.

About a month later, Chicago experienced a spell of severely cold weather and high wind. Fruit shipments continued heavy and house temperatures were more difficult to maintain. The operating engineer's solution was to increase steam pressure to 15 lb. This resulted in the same complications met with during the 20-lb. test, and the contractor was instructed by the owners to find the cause of the difficulties and remedy them without delay.

Another thorough inspection and test was made for defective steam traps or obstructions in pipe lines, but no defects were found. It showed, however, that the condensate passed through the return traps into vacuum return mains at such high temperatures that it flashed into vapor in the lower return line pressure, and made it impossible for the vacuum pumps to function properly.

The contractor, C. W. Johnson, Inc., reported these findings to the owners, and proposed to remedy the trouble by installing additional radiator surface at each fan intake and shunt the high temperature condensate discharged through steam traps through the proposed cooling surface before it entered the vacuum return line. The suggestion was approved and the work was started the following day. The units close to the boiler house were completed first, and in a very short time the change had been made in the eight units. The changes made corrected the trouble and the plant has been operated since that time at pressures up to 20 lb. with entirely satisfactory results.

Nine sections of 40 in. heaters (5⅜ in. centers) of 96¾ sq. ft. were suspended horizontally about 8

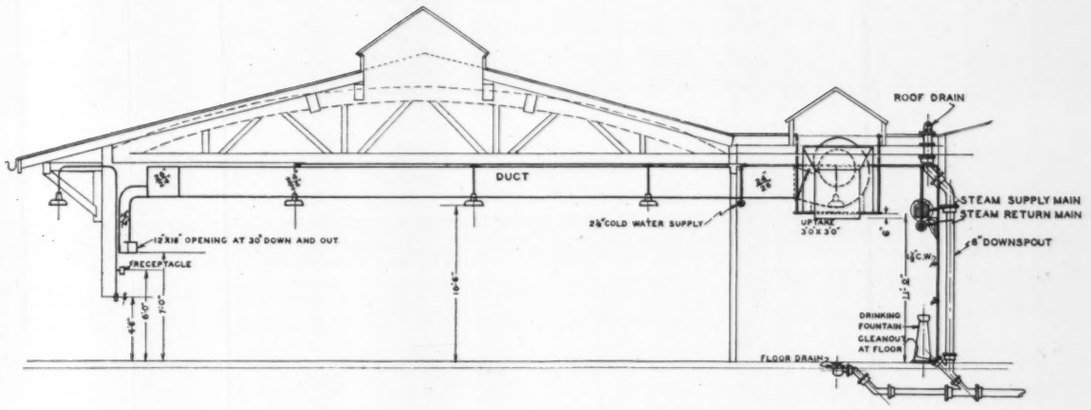


FIG. 3—A TYPICAL ELEVATION SHOWING THE LOCATION OF THE FAN, DUCT, AND STEAM LINES

inches below each fan intake, as shown in Fig. 4. The main drip and returns from the drain traps on each group of finned heaters were connected into a 1¼-in. pipe which was connected into the upper tapping of heater stack. From the lower tapping on the opposite diagonal corner, a connection was made with 1¼-in. pipe into the vacuum return line.

Temperature records showed an increase in temperature in the building of 5 to 9 deg. over a steam pressure range of 5 to 20 lb., due to this added radiation and improved vacuum pump performance. There was also entire freedom from high temperature vapors in the return system. The vacuum pumps functioned perfectly, maintaining any desired vacuum pressure continuously. Eight inches vacuum at the pump seems to give the best and most economical operating results.

One-day chart recording instruments give 24-hour records of temperatures throughout the building, outside temperature, boiler pressures and vacuum pump operation. These charts are carefully checked and filed. On several occasions they have been used as evidence in disputes arising out of claims for damages for produce alleged to have been frozen while in the building.

It may be of interest to record here that at no time since the heating plant was put in operation has the temperature in this fruit terminal building fallen below 32 F.

The contractor on this job was C. W. Johnson, Inc.; architects, Gallup & Joy; and mechanical engineer, Walter C. Ellis, all of Chicago.

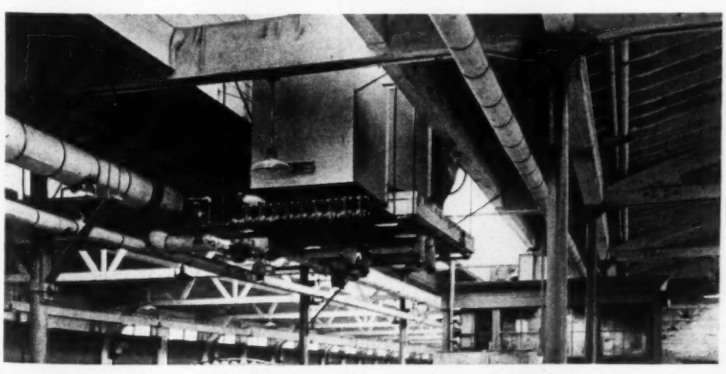


FIG. 4—ONE OF THE FAN INTAKES, SHOWING THE HEATER

Steam Header Connections

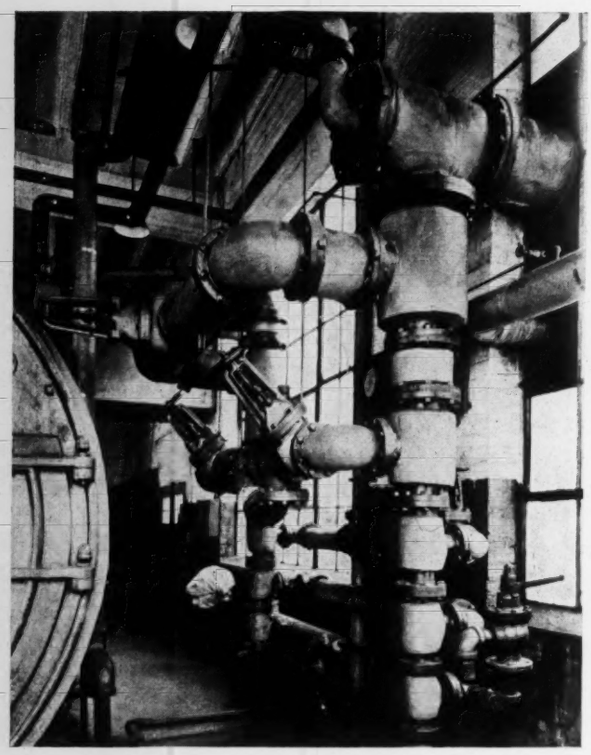
THE illustration on the next page shows the arrangement of reducing valves delivering steam into the 12 in. heating main serving the 100 ft. by 800 ft. building of the Chicago Produce Terminal Co., Chicago, the heating of which is described above.

The engineers' layout originally showed the reducing valves and by-passes to be installed overhead, suspended from the roof construction of the new power house in the manner usual for this type of installation. However, because of unforeseen delays in the construction of the power house and the necessity for supplying heat to the main building on the day set for its opening, the boilers were erected and connected before the masonry walls and chimney were completed or the roof construction begun. The floor slab and ash pits had already been completed.

The piping was held in position by temporary supports resting on the floor and the reducing pressure valve connections installed as illustrated. The 8 in. high pressure header dropped toward the floor, reducing to 3 in. at the bottom.

The heating system header was installed vertically, about 10 ft. east of the high pressure header. Two pressure regulators with control valves and the by-passes were installed in tiers, between these headers. A 2½ in. safety valve set to pop at 25 lb. was placed at the bottom of the heating header. The steam trap draining the boiler pressure header discharges into the heating boiler, while the trap draining the heating system header is connected into the vacuum return header through a cooling pipe.

For convenience of operation and to con-



Reducing Valves Delivering Steam to 12-In. Main

serve aisle space, the smaller (3 in.) by-pass was installed near the bottom of the header with the 3 in. pressure regulator next above, followed by the 5 in. pressure regulator about 5 ft. above the floor and above it an 8 in. by-pass.

The exhaust steam from boiler feed-pumps is connected into tee in 12 in. heating main at top of heating header through an oil-separator.

The chimney and the boiler room piping was completed and the entire heating plant put in operation before the re-enforced concrete roof slab was finished. A short time after the roof construction was ready to receive the weight of piping, etc., the temporary supports were removed and piping hung permanently from inserts in roof slab.

The location of reducing valves permits opening and closing of control valves and small by-pass valve from the floor. This is particularly convenient in this plant where steam demand fluctuates frequently during any 24-hour day.

The regulating valves have required no repairs and have operated perfectly since their installation.

The contractor on this job was C. W. Johnson, Inc., Chicago.

N. D. H. A. Convention

CO-OPERATION between the architect and the district heating company is essential to the economical heating of any building, according to Sterling S. Sanford, in a paper presented before the twenty-first annual convention of the National District Heating Association held last month in St. Louis. Describing the heat utilization work as carried on in Detroit, Mr. Sanford said that architects designing structures to be heated by the central steam company submit plans to be checked by the heat utilization engineers in order that the customer's steam consumption might be reduced.

Such utilization work does not stop after the building is erected, it was pointed out. Instructing operating personnel in the proper times to turn steam on and off and standing ready to co-operate with customers at all times on any question of heating are also parts of heat utilization activities.

In the report of the research committee, by E. E. Dubry, chairman, comparison was made between an industrial and business steam district, and the advantages of the industrial area to district steam were enumerated.

A study of residential and apartment house heating when this class of business is not adjacent to the existing system was also included in this report and the third topic considered was the steam accumulator and its uses in district heating. It was concluded that accumulators were especially adaptable to a load with a high peak of short duration rather than a moderate peak of long duration.

In the station operating report, the committee being under the chairmanship of H. J. Bauer, the general topic was divided into new plants and additions, boilers and furnaces, fuel burning equipment, feed water treatment, and station records and statistics.

The report on operating statistics consisted principally of a summary of operating data supplied by forty-three companies, an increase of five companies over those reporting last year. Among the conclusions reached by analysis of these data was that there were no notable changes in steam pressures, although three companies advised of proposed increases. A. D. Leach was chairman of this committee.

The report of the commercial relations committee was confined to water heating, including the installation of and requirements of hot water heaters and economy coils. According to L. S. Smith, chairman, definite procedure is needed to obtain more accurate data on this subject; in some cases, efficiencies of over 100 per cent were obtained, even after careful readings had been taken.

Based upon a study which showed rather variable results, the committee recommended that 0.6 to 0.8 lb. steam per cu. ft. water htg. be used for estimating in office buildings. About four times that, or 2.6 to 3.0, was recommended for hotels.

Other reports presented included that of the hot water committee, the meters and accessories committee (which stressed the increase in use of demand meters) and the distribution committee report, which covered corrosion, and concrete and brick conduit.

A paper by Paul Helm on the change-over from hot water to steam in Indianapolis last summer was received with considerable interest. Because of the necessity of having the system ready to operate at the start of the heating season, any bond meant nothing, said Mr. Helm, and everything was done to push the work on through.

L. A. Harding, president of the *American Society of Heating and Ventilating Engineers,* spoke on the applications of heating and ventilating research.

L. S. Smith, of the Rochester Gas & Electric Corporation, was elected president.

Notes on Hydraulic Power Systems and Piping

By E. W. Sylvester*

THESE notes on the design, installation, and operation of hydraulic power systems apply specifically to the applications of hydraulic power to certain shipboard auxiliaries. However, the principles of design discussed below apply to hydraulic power systems in general. These notes are based on experience with hydraulic systems in which the pressure medium is a light lubricating oil (200 seconds Saybolt at 100 F) and in which the maximum working pressures do not exceed 1,200 lb. per sq. in.

The shipboard applications of hydraulic power include the operation of steering gears, anchor windlasses, cranes, hoists, doors, heavy valves, and clutches. These auxiliaries are operated by hydraulic rams in such installations as require linear motion; and by hydraulic motors in those installations in which the motion required is rotary.

The selection of hydraulic power for the operation of each of the above auxiliaries is based on realizing one or more of the following advantages of hydraulic power transmission:

(1) Powerful, positive, and readily controllable linear motion may be obtained by the use of hydraulic rams without great frictional losses.

(2) Hydraulically-operated heavy duty machinery may be rapidly accelerated and decelerated without shock by delivery control of the hydraulic pump.

(3) Practically perfect speed control of hydraulic operating gears (ram or motor type) can be realized by the use of variable delivery pumps. By the employment of such pumps the speed of the driven gear can be varied at will through a continuous range from full speed in one direction to full speed in the opposite direction while the speed of the pump drive remains constant.

(4) In installations in which the delivered torque required may greatly exceed the normal torque requirements, automatic control of the delivery of a variable delivery pump provides a means of meeting the higher torque requirements without overloading a prime mover rated for normal operating conditions.

Uses of Hydraulic Power Afloat

Figs. 1, 2 and 3 illustrate diagramatically the piping arrangements of the three general types of hydraulic power installations used aboard ship; viz., a variable delivery pump and ram type operating gear, illustrated by the steering gear in Fig. 1; a variable delivery pump and hydraulic motor, illustrated by the capstan operating gear in Fig. 2; and a constant displacement pump used in conjunction with an accumulator, as illustrated in Fig. 3.

Hydraulic Power Used Ashore

The shore applications of hydraulic power in which the advantages of this transmission indicate its use include, in addition to its familiar use in the operation of presses and elevators, the operation of heavy machine tool feeds, paper manufacturing machinery, heavy valves, and flood gates. Three of the more novel applications of hydraulic power which have come to the writer's attention are the use of a variable delivery pump drive on a winch used in the construction of a suspension bridge for hauling over the individual strands of the master cables between cable towers in the operation of building up the master cables, in which operation an exact control of hauling speeds was required; the use of a variable delivery pump in the operation of a drawing press where it was necessary to vary and accurately control the speed of the press to suit varying physical

* Lieut., Construction Corps, U. S. Navy.

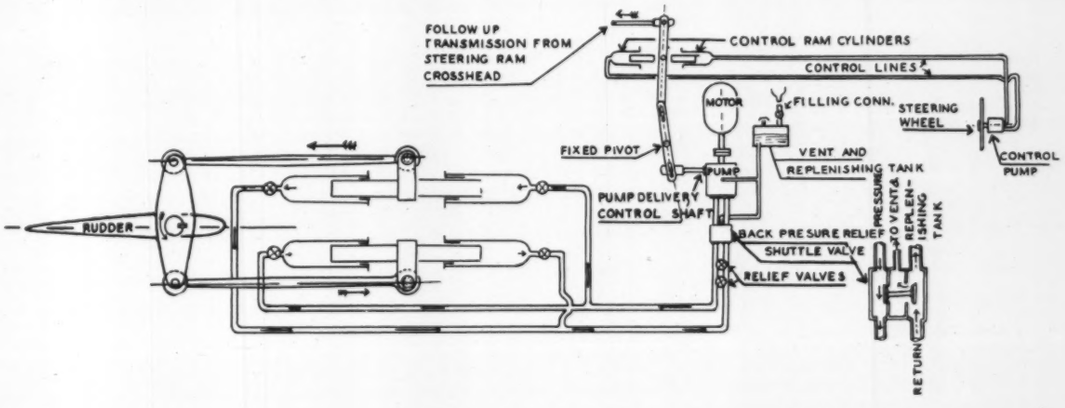


FIG. 1—A TYPE OF HYDRAULIC STEERING GEAR, ILLUSTRATING AN APPLICATION OF A VARIABLE DELIVERY PUMP IN CONJUNCTION WITH RAMS.

conditions of the material in process; and the use of a hand pump operated hydraulic brake for applying a frictional load on a wire rope checking line secured to a vessel launched in restricted waters.

Some of the problems encountered in the design and installation of hydraulic power piping systems are discussed below.

Pipe Sizes

The general practice in proportioning pressure and return lines of hydraulic piping in shipboard installations has been to base the pipe diameter on a speed of flow of approximately 15 f.p.s. in systems in which the flow is more or less continuous. Somewhat higher velocities

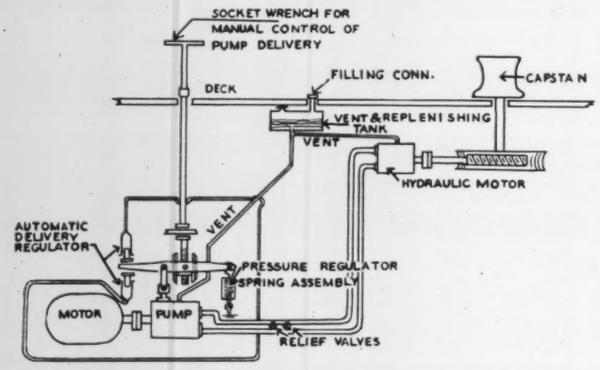


Fig. 2—A Hydraulic Capstan, Illustrating An Application of a Variable Delivery Pump in Conjunction with a Hydraulic Motor Unit

have been considered acceptable in lines to small ram type operating units whose operation is intermittent.

In systems in which return lines are led to a sump tank or head box, pump suction piping should preferably be of sufficiently great diameter to insure that when the pump is operating at full delivery the static pressure in the suction port of the pump will not fall below atmospheric pressure. This diameter depends, of course, upon pump displacement, speed and stroke, length of suction piping (including the equivalent lengths of fittings), viscosity and density of the pressure medium, and the height of the sump tank or head box with respect to the pump. For hydraulic systems in which water is the pressure medium this diameter may be readily picked out from handbook flow charts.

The desirability of maintaining a positive pressure in the suction ports of pumps is based on experience with certain variable delivery multi-cylinder pumps and covering a range of piston speeds from 50 to 200 f.p.m. It was found that when the pressure on the suction side of these pumps fell below that corresponding to a vacuum of 5 in. of mercury, violent vibration and noise resulted which was transmitted to, and throughout, the entire pressure system and which resulted in leaks, piping failures, loss of efficiency, and excessive wear and tear on the pumps, to say nothing of the wear and tear on the nerves of operating personnel.

Factors of Safety

In selecting a factor of safety to be used in hydraulic piping design, due consideration must be given to the shock stresses to which these systems may be subjected. In naval work with which the writer is familiar a factor of safety of 10 is used.

Venting

To obtain shockless, quiet, and uniform operation of hydraulic power systems it is essential that air be eliminated from the system. Arrangements for venting all points in the system at which air might otherwise be pocketed must be made. Needle valves located at these points provide a means of occasional venting. Continuous and automatic venting may be provided by the installation of so-called "air-drain coils." Such a drain is a coil of a number of feet of very small tubing, one end of which connects to the point in the system to be vented and the other end to a pipe leading to the sump or expansion tank of the system. As an illustration of the proportions of these drains, an air drain described by Messrs. Sol. Einstein and Hans Ernst in a paper on hydraulic feeding mechanisms for milling machines is specified as being "a tightly wound coil of about 36 ft. of 0.045 in. bore copper tubing." Such tubing provides a ready escape for air, while the leakage of oil through the tubing is insignificant.

Much can be done toward the simplification of venting arrangements by careful attention to the lay-out of the piping, with a view toward minimizing the number of high spots in the system and purposely locating high spots at points in the system which can be most conveniently vented.

Vent lines, lines from relief valves, and return lines to sump tanks should enter the tanks below the level of the oil in the tanks to maintain a closed system and avoid entrapping air in the pressure medium. In a test installation set up by the writer, the return line was inadvertently led to the top of the supply tank. Soon after starting the pump, the system became very noisy and eventually the sump tank overflowed, due to the effective increase in volume caused by the emulsification of the pressure medium. Upon changing the inlet of the return line to the bottom of the tank the above difficulty was overcome.

Materials of Piping

Copper, brass, and steel tubing are used in shipboard hydraulic power systems. Extension of the use of seamless drawn steel tubing, especially in high pressure applications, is indicated.

Pipe Joints

No more severe duty is required of any pipe joint than that imposed on joints in such high pressure hydraulic power systems as are subjected to shock and vibration.

Male and female steel flange joints made up with copper asbestos gaskets, cone type couplings, and sweated sleeve couplings have been successfully employed in shipboard systems.

The cone type coupling was developed to save space as compared with flange joints in the restricted locations in which this piping must be run in submarines. The cone joint referred to is described in the March 1930 Heating, Piping and Air Conditioning.

The sweated sleeve coupling is also used. This sweated sleeve coupling is also described in the above-mentioned issue of Heating, Piping and Air Condi-

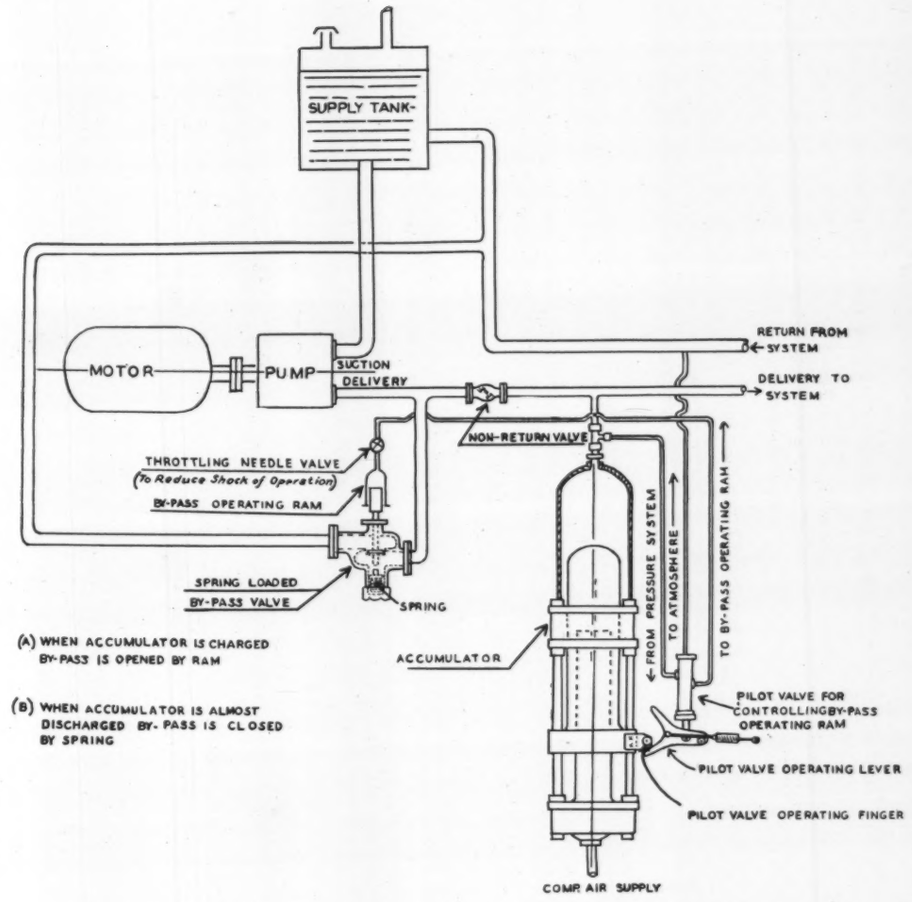


FIG. 3—A CONSTANT DISPLACEMENT PUMP-ACCUMULATOR HYDRAULIC SYSTEM

TIONING. It is nothing more than a brass sleeve having an internal diameter just large enough to permit "ringing" the sleeve over the pipe with which it is to be used. The inside of the sleeve and the outside of the pipe ends are tinned. The sleeve is heated and threaded over one pipe end. The other pipe end is brought into place and the sleeve centered over the butt. The whole joint is then heated.

Upon cooling, a tight joint results. This joint was originally developed for brass and copper pipe, although recent experiments have shown it to be entirely suitable for steel tubing. Fig. 4 shows a steel pipe fitted with a brass sleeve which was tested to failure of the pipe at 9,000 lb. per sq. in. without leakage or failure of the sleeve joint.

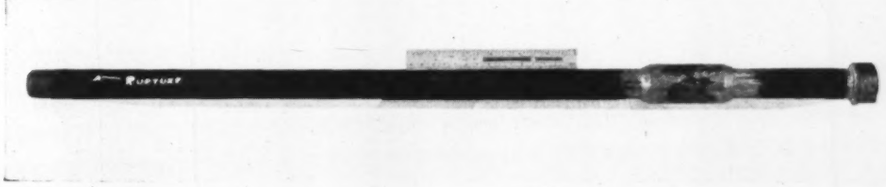
Experimental sleeve joints have been tested in a shipboard hydraulic system over a period of four years. They have been subjected to numerous pressure and vibration tests. Such a connection is easily assembled and disassembled. The use of sleeve type couplings is not restricted to making straight joints. They may be employed in making up tees, ells and crosses as well.

There has been no extensive use of electric welded joints in steel tubing used for piping hydraulic systems. In one installation, however, with which the writer is familiar, arc welded sleeve joints were used in making joints in steel piping in a hydraulic system in which the working pressure was 600 lb. per sq. in. and which was subjected to constant vibration. These joints have been in service over a period of two years. They were made in a 2-in. line.

Fittings

Most of the valves, fittings and manifolds of shipboard hydraulic systems with which the writer is familiar are

FIG. 4—SWEATED BRASS SLEEVE COUPLING ON 1.05 IN. STEEL TUBING TESTED TO RUPTURE OF TUBING AT 9,000 LB. PER SQ. IN. INTERNAL HYDROSTATIC PRESSURE



cast in Composition *G* (gunmetal) or steel. It is understood that for some years there has been considerable difficulty encountered by various manufacturers in making sound Composition *G* castings which will stand hydraulic pressure and that the tendency has been to substitute the less strong Composition *M*, which contains a higher per cent of lead and in which it is, therefore, easier to secure non-porous castings. Those readers who may be confronted with this problem are referred to a paper by Captain L. Shane, U. S. Navy, published in the November 1929 *Journal* of the *American Society of Naval Engineers* in which it is pointed out that the difficulty in making Composition *G* castings arose almost contemporaneously with the introduction of the open flame furnace. Captain Shane sets down in detail the exact foundry practice which has resulted in a material reduction of rejections of Composition *G* pressure castings at establishments at which this practice has been adopted and followed in detail.

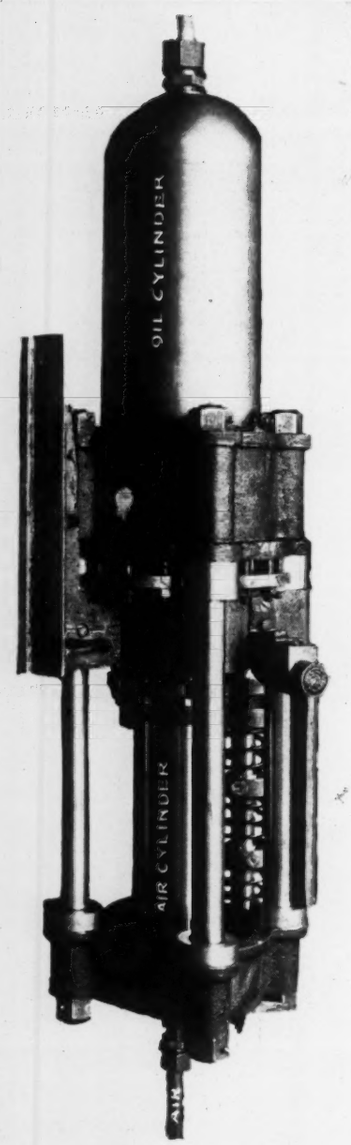


FIG. 5—AN AIR-LOADED HYDRAULIC ACCUMULATOR

Use of Cast Steel

The use of cast steel for fittings, valve bodies, and manifolds is being extended to save weight by the use of this material in high pressure systems where the designed wall thickness of these parts, if made of non-ferrous castings, would be greater than the least wall thickness with which it is practicable to obtain steel castings.

Cleanliness of Systems

Great care must be exercised to insure that no solid particles shall enter hydraulic piping systems in order to protect the pumps, hydraulic motors, rams and valves. Hydraulic pumps and motors are designed with very small clearances between pistons and barrels.

Strainers should be installed in filling lines and suction lines should be taken off from sump tanks or head boxes at a level a few inches above the bottoms of these tanks in order that such sediment as may settle to the bottom of the tanks will not be drawn into the system.

The following precautions to secure cleanliness of hydraulic piping systems are quoted from instructions of the Bureau of Construction and Repair of the Navy Department:

"When installing or replacing piping or fittings, care must be taken to remove all foreign matter.

"All parts shall be thoroughly cleaned by wire brushing and wiping with cotton rags. If necessary to remove scale, pickling and sand blasting should be used, care being taken to neutralize and wash off the pickling solution. Places not thoroughly cleaned by the above method should be scraped.

"The unfinished interior surfaces of castings, after final cleaning as above, should be given a coat of thin shellac and air dried; then heated by blow torch or in an oven until shellac softens, and then allowed to harden in air. This will tend to prevent the working out of particles from small crevices. It is very essential that thin shellac be used, so that no lumps or runs are left on the surface, which might later flake off and gum up the working parts."

Gages

Gages on such hydraulic systems as are subjected to shock and vibration must be protected. The installation of coils of fine tubing in the gage lines affords protection against damage due to such conditions of rapid pressure fluctuation. The length and size of tubing to be used for this purpose are functions of the working pressure and the pressure fluctuation characteristics of the system in which they are to be used. Gage protectors suitable for use in any installation in which they may be required are commercially available. These gage protectors may also be utilized in lines leading to automatic control units, such as pressure regulators and by-pass valve operating rams, to obtain fineness of control and shockless operation.

The use of seamless drawn copper tubing and commercial cone type fittings similar to those used in automotive practice has been common practice in making up hydraulic system gage lines.

Noise

Noisy operation of hydraulic systems and the ills of which noise is a symptom may usually be traced to insufficient suction or return systems, entrapped air or vapor, or faulty pump design. The first of these causes is discussed above under *Pipe Sizes;* and the second under *Venting.* The third is beyond the scope of this paper.

Operation shocks may be minimized by providing for gradual opening and closing of control valves and the likelihood of damage due to shock reduced by the installation of shock valves in the immediate vicinity of ram type operating gears.

The weight of cell concrete depends upon the amount of foam added to the mixer. According to the Portland Cement Association, its weight may be as low as 20 lb. per cu. ft., but usually varies from forty to fifty.

Humidity—Its Relation to Humanitarianism and Commercialism

By William M. Trafton

IT IS a well known fact that a temperature of from 65 to 72 F, with a relative humidity of from 60 to 65 per cent, is beneficial to health and at the same time well within the comfort zone, according to research made by the *American Society of Heating and Ventilating Engineers.* Such temperatures are available during the fall and winter months in the average textile mill, by the application of heat controllers, and these lowered temperatures are reflected in a further economy in the coal pile, and an increased productivity on the part of the worker.

We will admit, however, that in certain departments of the textile mill higher temperatures and higher humidities than these referred to are necessary. In the absence of artificial humidity at the higher temperatures, however, the effect on the worker is more injurious and is reflected in the loss of production, more than many of us realize.

Dr. W. W. Wilson, of the *U. S. Weather Bureau,* says this in writing about the effect of humidification on health:

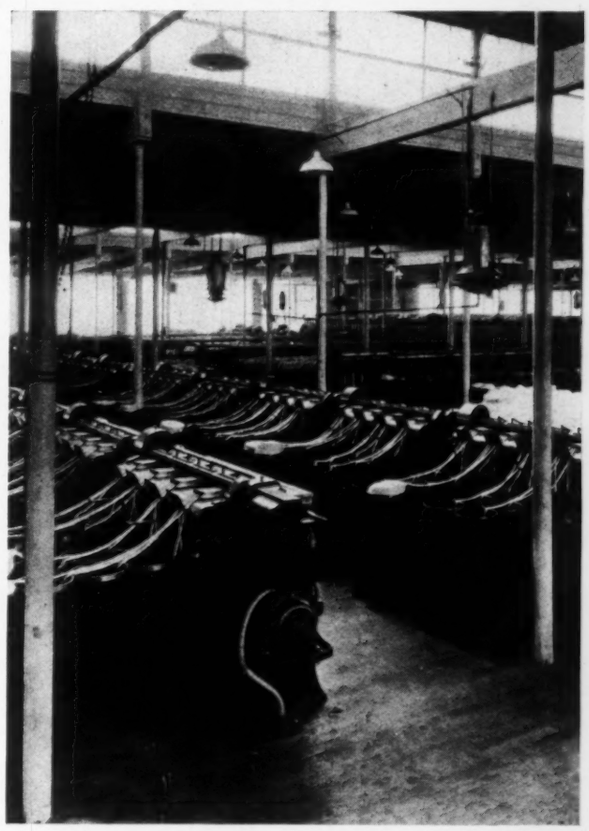
"The evaporate power of the air at a relative humidity of as low as 30 per cent is very great, and when the tissues and delicate membrances of the respiratory tract are subjected to this drying process, a corresponding increase of work is placed upon the mucous glands to keep the membrane in proper physiological condition. Nature, in every effort to compensate for the lack of moisture in the air, is obliged to increase the functional activity of the glands, and this increase of activity and the frequent unnatural stimulation induced by the changing conditions of humidity from the moisture-laden air outside to the arid atmosphere within our buildings, finally results in an enlargement of the gland tissues, on the same principle that constant exercise increases any part of the same animal organism. Not only do the glands become enlarged, but the membrane itself becomes thickened and harsh, and sooner or later the surface is prepared for the reception of germs and disease which tend to develop under exposure to the constantly changing percentage of humidity."

We are all familiar with the regulation of humidity in theaters and public buildings, and in hospitals and operating rooms. Physicians and laboratorians are more and more advocating the use of humidification in buildings where people are congregated, to obviate the drying of the mucous membrane of the nose and throat, which when dry presents an admirable breeding place for microbes and germs.

The Human Element

Forget for a moment, if you will, the use of humidity as a purely production factor in textile mills. Think of it in terms of the human element, which is so vital a factor in the operation of every industrial enterprise. I believe that it would pay the employer to humidify his mill strictly on this account; namely, to keep the employe in better health, consequently less susceptible to colds, influenza, pneumonia, and kindred ills of the respiratory tract. Better general health in the mill obviously means less labor turnover and there is no doubt but that proper humidification, with proper air change, is a vastly important factor in improving healthful conditions, as against what they would be in the hot, dry and stagnant air in the ordinary mill with no proper humidifying system.

There is another consideration in connection with this subject, which we have not touched upon, and that is the air washing and the air circulation which is induced by a modern humidifying system. A large portion of the air is washed and thereby cleansed, and the air content of the room is re-circulated many times. Such conditions add to the healthful comfort of the employes,



THE DRAWING DEPARTMENT IN A GEORGIA MILL, SHOWING HUMIDIFIERS

Excerpts from a paper prepared and read at a meeting of the National Cotton Manufacturers' Association by William M. Trafton, Vice President and General Manager, American Moistening Co., Providence, R. I.

and thereby increase their productivity, as everybody knows a well man can work better and accomplish more than a half-sick one.

So much for the effect of humidity on the employe during the winter months. Now, let us consider the summer months and what humidity can do for both the employer and the employe during this time.

Maintaining Healthful Conditions in the Weaving Room

We all realize that our productivity during the summer months when the heat is oppressive is lower than it is during the fall and winter months, when we can regulate and control the heat. Therefore, anything that can be done in the mill to reduce the temperature will react not only to the comfort of the employe, but to his productivity. As we are obliged to have humidity in our manufacturing processes, it is only a step, or an increase in humidifying capacity, to obtain the lowered temperature referred to.

Let us take, for illustration, a weaving room, the dimensions of which are 450 by 100 by 15 feet, which equals 675,000 cubic feet. This particular room happens to be on the first floor, and we have a total of 100 windows. Assuming that we have outside weather conditions of 100 F and 25 to 30 per cent relative humidity, by introducing approximately 2,000 pounds of water per hour into the air in this room through a modern humidifying system, we are not only absorbing the heat generated by the 450 hp. needed to operate the machinery but we are giving the employe a working temperature of 88 vs. the 100 F outside. Furthermore, while he would be working under a rather excessive humidity condition, we would require only 75 to 80 per cent relative humidity to attain this reduction in temperature of 12 deg. under the outside temperature. Not only would the workman be more comfortable because of the lowered temperature, but, due to the fairly rapid air change in the room, the sensible temperature would make for more comfortable working conditions.

Humidification for Manufacturing Processes

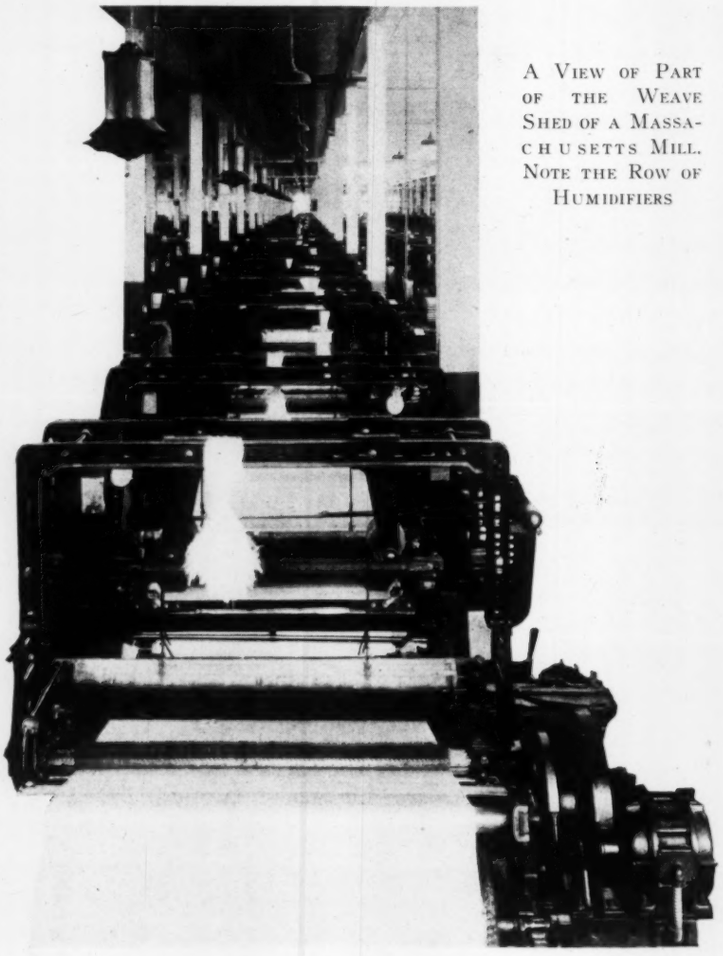
This subject has been considered and debated so many times from the standpoint of the mill man that it would seem that nothing more could be added to what has already been said and published on this subject, but while we all know the effect of humidity on the breaking strength and the elimination of static electricity in the manufacture of cotton yarns, I believe (and this belief is further substantiated in talks with textile mill men) that there are several phases in connection with the application of humidity which are not realized by the management of some of our cotton mills.

How One Mill Cut Cost

All mills are endeavoring to cut the cost of their production to the minimum, and here is the way that one mill cut cost after introducing an adequate humidifying system. The mill was manufacturing cords and twines which sold at an average price of thirty cents per pound, the output being 40,000 pounds per week, or in dollars—$12,000. They never had used controlled humidity, and the agent of the mill stated that if it could be shown him whereby a humidifying system would be a profitable investment, he would install it.

It did not take an engineer long to ascertain that he was shipping out his twine with an average regain of only 4 per cent in moisture. When the agent was shown that he could add 3 per cent or more of moisture legitimately to his product, or get an increase of 1,200 pounds per week in his production at thirty cents a pound without using any more cotton, thereby making an additional profit of $360 a week (or a gain of over $18,000 a year) that settled the question in his mind.

This man, however, awoke to the fact that the introduction of controlled humidity had greatly increased his breaking strength, and as he put it, "My cords and twines were strong enough before introducing controlled hu-



A View of Part of the Weave Shed of a Massachusetts Mill. Note the Row of Humidifiers

As we are obliged to have humidity in many manufacturing processes, it is only a step (or an increase in humidifying capacity) to obtain lower temperatures.

midity; therefore, under these circumstances why should I not use a cheaper grade of cotton in the manufacture of my product?" The outcome of it was that he experimented, and is today using cotton which is costing him between 1 cent to 1½ cents a pound less than his former grade. Therefore, he is saving $18,000 to $20,000 a year because of his moisture regain; conservatively, 1 cent a pound or over $20,000 a year on his cotton—a total saving of about $40,000 per annum, and all because he installed a humidifying system which showed him a profit on his investment of 700 to 800 per cent per annum.

Another case is a yarn mill, where they made a comparatively cheap grade of yarn which they used in the manufacture of lace curtains. Their results under controlled humidity were not as great as the cord manufacturer, but in addition to an increased regain which they obtained, they now mix a bale of cotton such as they formerly used with a bale of a shorter staple and lower-priced cotton, which gives them a saving of 1 cent per pound.

Humidifying Equipment in the Cloth Room

There is another place where I find that many mills in the North are loath to install humidifying equipment, whereas the Southern mills install it without a question. I refer to the cloth room.

Buyers are becoming more and more insistent on the weight of the goods received by them. In a particular case that I have in mind a buyer had been arguing with the mill on this very point. The argument, however, was settled to the satisfaction of both buyer and seller by the introduction of a humidifying system in the cloth room and, curiously, to the material financial advantage of the mill. Here is how it worked out:

The material which the mill sent out previously with a comparatively low moisture content was benefited by the humidity not only as to increased weight, but the "feel" of the goods was so much better that the buyer thought that the mill had changed some of its processes in the manufacture of the cloth. While the difference in "feel" was due entirely to humidity, I happen to know that this particular mill has not tried to disillusion the buyer as to his idea that the mill had changed the manufacturing process.

There has been much discussion and argument over the question of selling water in place of cotton. Naturally, no self-respecting manufacturer expects, or even wants, to do this, but, on the other hand, when a mill buys cotton with a moisture content of from 7 to 8 per cent and its manufactured product goes onto the market with a less percentage of moisture and is sold by weight, that mill is simply giving away a profit that legitimately belongs to it, as the mill actually bought water and replaced it with cotton. We have known of mills in the past where the difference in the moisture content between the cotton purchased and the product sold constituted the difference between actual profit and loss on the mill's operation.

Humidification in a Cereal Factory

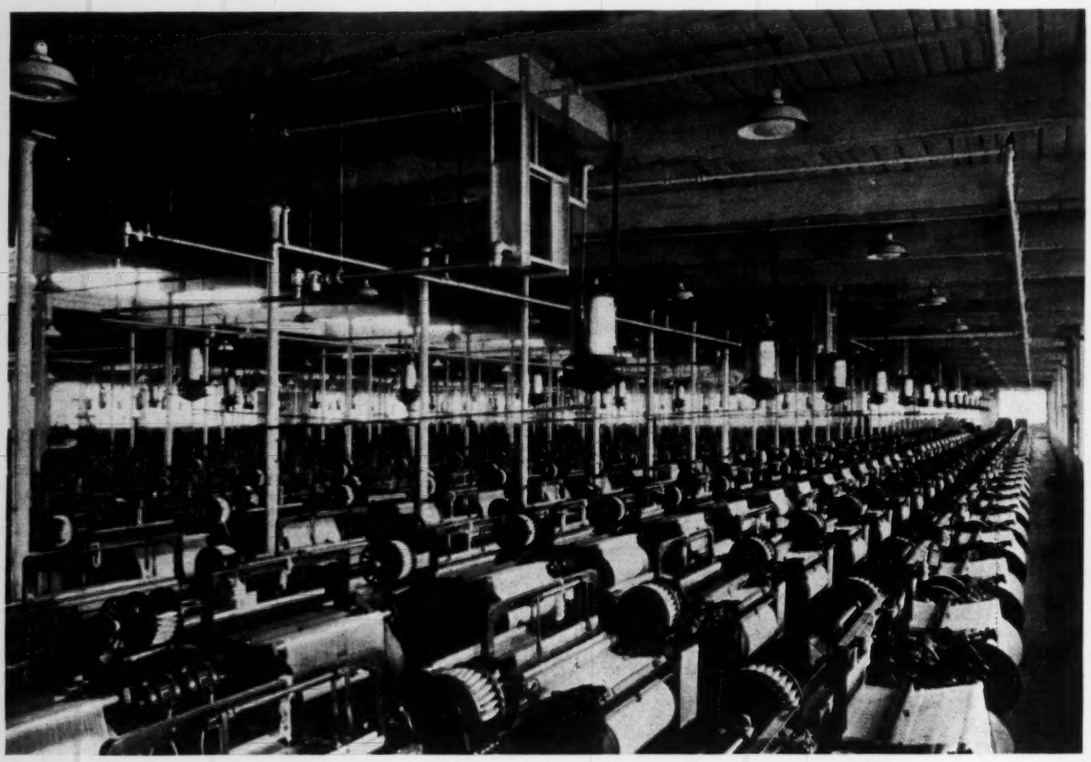
Here is another illustration which brings home my point clearly. An inquiry came from a manufacturer of a cereal breakfast food, and it was noted that during the process of manufacture the breakfast food had to be heated or toasted, and that from this process it was immediately placed in a carton to go to the ultimate consumer, the contents of the carton weighing one pound.

It was found, however, that if this cereal was cooled and allowed to stand for a while, it gained a considerable natural moisture. Thereupon, another simple process was introduced for cooling the cereal flakes, and a humidifying system was installed which would hasten the natural moisture regain, after which the cereal was packed in the carton, with a resultant increased profit for the manufacturer which amounted annually to a great many thousand dollars, because the output of this plant went into millions of packages of this cereal product.

Fly and Seconds

I have not touched on the additional saving which can be made by the installation of humidification systems, by reducing to a minimum the invisible loss, or fly, in the various preparatory or intermediate processes of manufacturing cotton goods. There is, however, another mill loss, which is the "bugaboo" of every agent and superin-

In Order to Maintain Quality Standards, One Large Paper Company Maintains a Test Room Kept Always at 65 Per Cent Relative Humidity and 70 F, Regardless of the Weather. Tests Are Made on All Paper in Process, and on the Finished Paper. The Cellulose Fiber From Which Paper Is Made Is Very Hygroscopic; Increased Moisture Content Causes a Drop in the Bursting and Tensile Strengths Up to 78 Per Cent Relative Humidity, Above Which a Rapid Drop Is Noticeable



A Weave Shed in Which Are Installed 92 Humidifiers, Automatically Controlled

tendent. I refer to seconds. In conversation with a mill superintendent in the South, who formerly had a very inadequate humidifying system, which however was finally modernized, he made the statement that he had cut his seconds in half since his up-to-date humidifying system had been in operation.

An Industrial Gas Heating Installation

By Joseph W. Piatt*

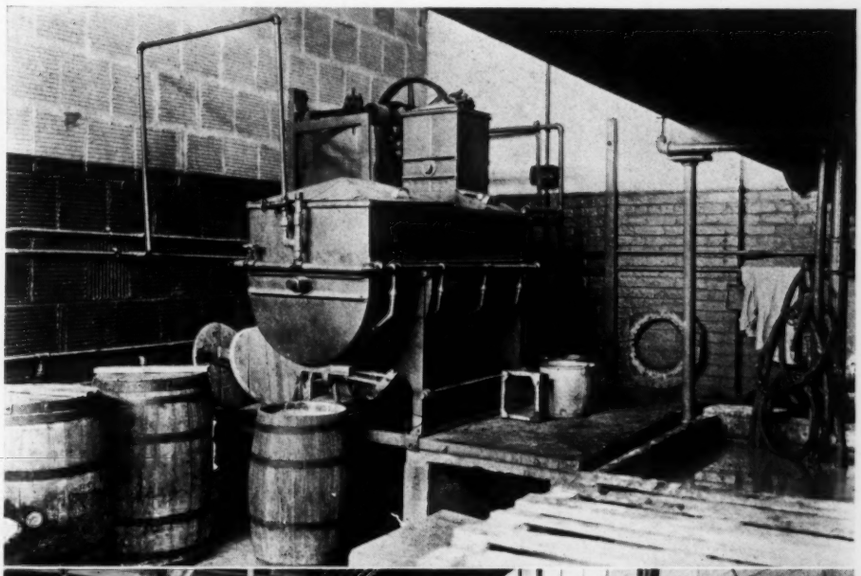
ALFRED BLEYER & CO., of Brooklyn, N. Y., manufactures paper bags, paper lunch containers, paper dishes and paper devices for various purposes. A recently published article credits this firm with a daily capacity of 1,300,000 pressed-paper pie plates and 2,000,000 paper bags, besides its other specialties. All the heat used in this plant is furnished by city gas supplied by the Brooklyn Union Gas Company. The bulk of the products is produced by passing paper rolls, that have been moistened by spray from steam nozzles, into machines where, by one simple operation, they are stamped and pressed into the required shape. The finish on the dishes sometimes resembles fluting, sometimes it is a shell design, and there are, of course, many other variations. The plates come out of the machines thoroughly dried and ready for use. The paper bags, however, are sealed at the bottoms by paste.

Six large steam-heated stamping machines equipped to punch out and form a large number of plates at one stroke have been installed. The paper is fed into these machines in three superimposed layers from separate rolls so that the punch bolsters, which contain a large number of dies, strike off and form three plates for each die in one operation. The heating element for the dies in the bolster of the machine is steam generated by means of an automatic 10 horsepower gas steam boiler and fed through a trap return system. This insure economy in the use of fuel, as the waste steam or condensation is returned to the boiler, thus saving the heat required to raise cold water to the temperature equal to that of hot water returned to the boiler. Incidentally, this particular boiler also feeds the moistening bath mentioned before, which is an open system.

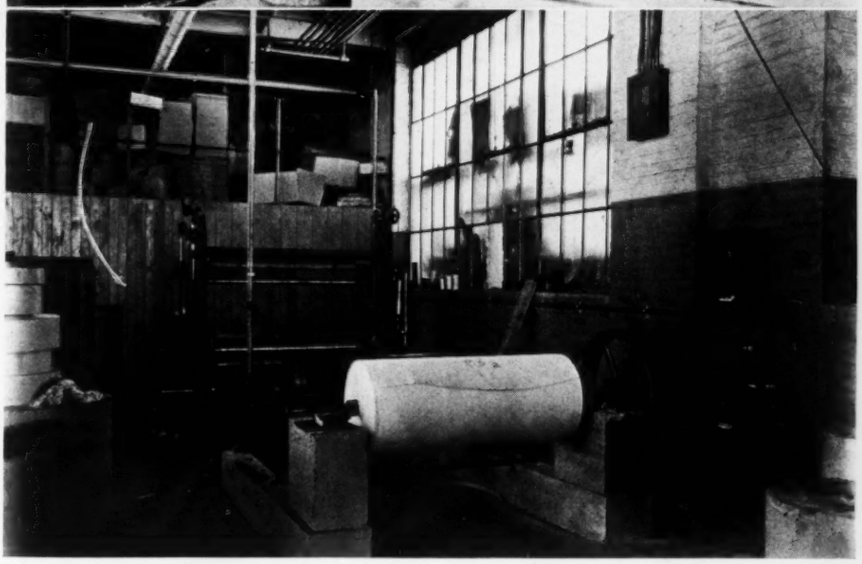
Because of the automatic features of this boiler, little attention is required to the heating phase of the plate stamping operations. The boiler can automatically take care of closed or return systems and open or exhaust systems at the same time, using the steam merely as a means of transferring the heat from the gas fire to the point where work is to be done. Such a combination can be operated with economy because the automatic devices permit only the amount of gas to go through the burners that is necessary to maintain the pressure at which the regulators are set.

As steam pressure is a distinct measure of the temperature of steam, it is a simple matter to convert pressure readings of steam to the thermometer scale. The

* Brooklyn Union Gas Co.



THE VAT FOR COOKING PASTE—OPEN SYSTEM



PAPER ROLL MOISTENING DEVICE IN THE OPEN STEAM SYSTEM

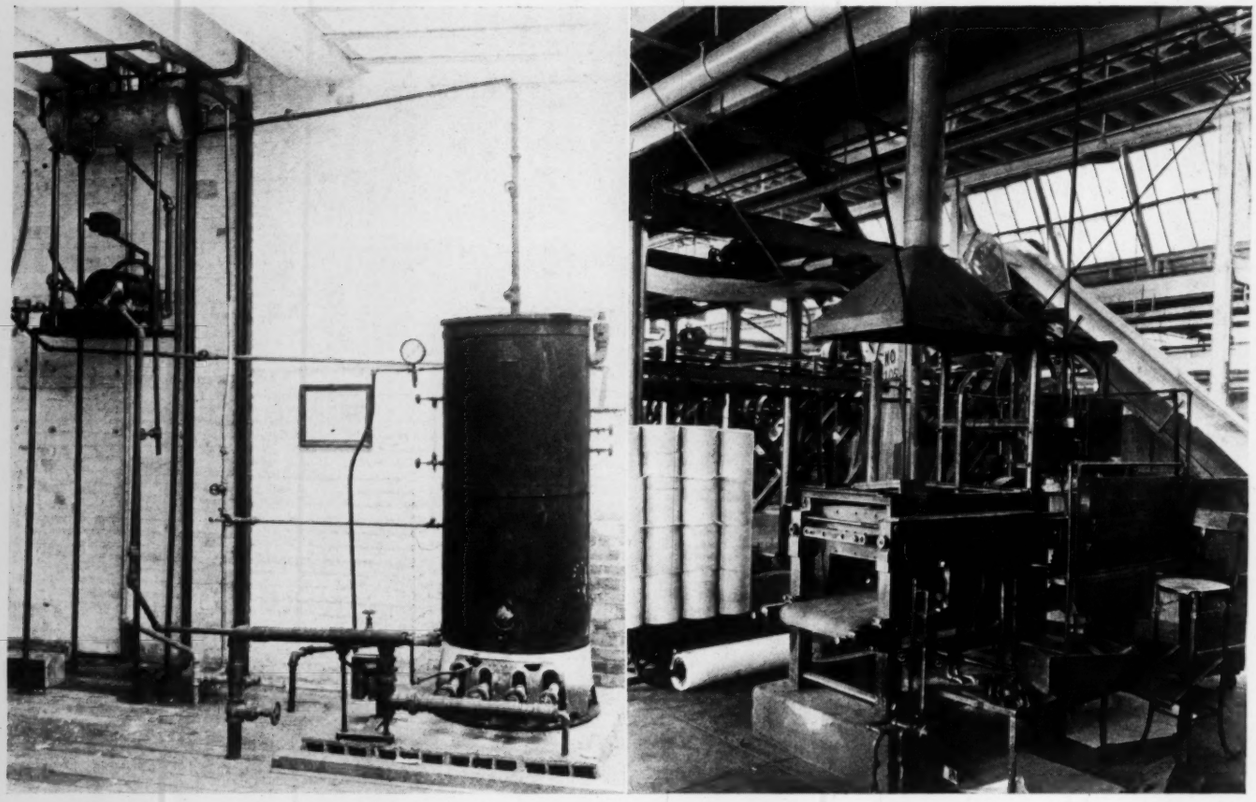
steam pressure in the boiler itself becomes a thermostatic regulator through mechanical devices that decrease or increase the amount of gas burned to maintain the pressure necessary to balance the weights on the lever of the steam diaphragm valve which controls the gas flow. By using weights and a lever similar to a balanced weighing scale, simplicity and reliability are assured, for the whole mechanism operates through the force of gravity and the thermal efficiency of the gas supply. A gas steam boiler with such an automatic regulating system is self-operating when fitted with water feeds and steam traps. The gas steam heated presses installed in this plant have a daily capacity of 300,000 butter chips, or with the appropriate dies they can produce 75,000 to 400,000 pie plates each day.

Piping

The 10 horsepower automatic high pressure boiler is located 250 feet from the inlet of the 2-in. steam pipe manifold that serves the six presses. The steam at 30 lb. pressure is carried to this manifold through a 1½-in. standard steel pipe covered with one inch of 85 per cent magnesia insulating material. This pipe is hung along the ceiling so as not to interfere with any of the activities of the plant. At the central point of the intake manifold, the 1½-in. feed line from the boiler drops down to a pressure reducing valve that feeds the steam into the 2-in. manifold at from 10 to 15 lb. pressure instead of the 30 lb. carried on the feed line. There is an indicating steam gage on each side of the reducing valve which is hand operated. This valve acts as a manually operated thermostat in conjunction with the two steam gages.

Each of the six large stamping presses has a moving upper bolster and a fixed lower bolster that contain the male and female dies. Steam enters the upper bolster from the manifold through a ½-in. armored flexible tubing, and after circulating around and into the heating chamber of the dies, it leaves this bolster through a similar ½-in. flexible tube, and passes through a ½-in. thermostatic steam trap which is connected to the 1½-in. return or exhaust steam manifold by standard ½-in. steam pipe. The lower bolster takes steam from the manifold through a rigid ½-in. steam connection as this bolster itself is rigid and its dies act as the receiving blocks for the striking dies in the upper moveable bolster.

Steam circulates in this bolster in the same way that it does in the upper bolster. The steam leaves this bolster through a rigid ½-in. steam pipe and also passes



(Left)—The High Pressure Gas Steam Boiler Showing the Boiler Feed System. (Right)—One of the Direct Gas-Heated Presses

through a ½-in. thermostatic steam trap from which it passes into the 1½-in. return manifold through a rigid ½-in. steam pipe. The condensation from the six presses is picked up by a three-valve lift trap and returned to the boiler by means of 250 feet of 1½-in. steam piping hung on the ceiling and a boiler feed system. The feed manifold of the presses is hung to the ceiling in front and above the bolster while the return manifold lies on the floor just in front of the machine. It is necessary to pick the condensation up and lift it to the ceiling in forcing it back to the receiving tank of the boiler feed system.

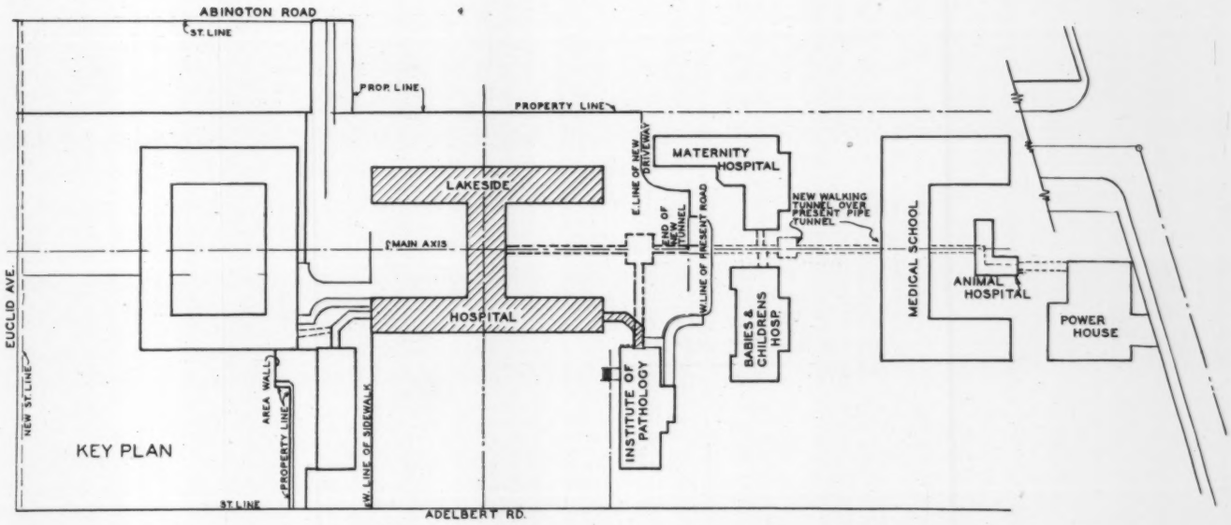
The cycle operation of the three-valve lift trap begins with atmospheric pressure when receiving condensation. When the trap is filled it automatically opens a valve in the ¾-in. high pressure steam pipe with which it is fed from the 1½-in. high pressure steam line that feeds the presses. The boiler pressure through this connection forces all the condensation out of the lift trap and back to the boiler receiving tank. The trap is then filled with high pressure steam which immediately exhausts itself through a valve which delivers it to the atmosphere. The trap then is at atmopheric pressure and the cycle is completed. This takes one minute of time. The trap then receives condensation from exhaust steam and a new cycle begins.

Boiler Feed System

The boiler feed system is necessary in order to supply the boiler with water to replace that lost in the open steam system. In this instance the boiler performance is a dual one comprising a closed system and an open system. The open system is fed from the same boiler outlet as the closed system just described. The open system consists of a 1-in. steam pipe carrying steam at boiler pressure to a 30 gal. vat in which paste for sealing paper bags is cooked at a temperature of 210 to 212 F fifteen feet distant from the boiler.

The 1-in. feed pipe, by means of a 1-in. branch line, feeds a paper moistening apparatus ten feet further from the boiler. This device consists of a winding machine which rolls three webs of superimposed paper which is moistened evenly at an approximate temperature of 80 F by means of steam jets. These rolls of paper are removed and fed into the presses. The steam used in the open system is lost to the boiler and is replaced through the boiler feed system from the city water supply. This system operates in conjunction between boiler steam pressure and city water pressure. The system is a standard appliance and as its operation is well known it need not be described here.

All steam piping is standard steel pipe rated as safe at a pressure of 100 lb. per sq. in. with the exception of the ½-in flexible piping mentioned in connection with the upper bolsters of the steam presses. The steam piping was tested by building up the boiler pressure directly in the pipes to maximum and inspecting for leaks. All steam pipes are insulated with 85 per cent magnesia pipe covering 1 in. thick. The gas for the boiler is supplied by a 2-in. gas line taking off the 4-in. gas feed line of the plant. This 4-in. line supplies a number of direct gas heated presses used in the plant. The operation of the boiler is standard and well known.



14 Carloads Radiators, 7 of Pipe Covering, 57 Fans *in* Cleveland Hospital Addition

By J. Hamilton

THE UNIVERSITY Hospitals group in Cleveland, Ohio, occupies a rectangle the length of two long city blocks and the width of one short block. It can be compared in size with the Presbyterian Hospital in New York City and the proposed Cornell University and New York Hospital. Also, like them, the Cleveland group combines both school and hospital. Students' laboratories are built in Lakeside immediately adjoining the patients' rooms in addition to the medical school proper, which is also a part of the group.

The first unit was started in 1922 and has been in use for several years. It comprises the Western Reserve Medical School and the power house. Babies' and Children's Hospital and Maternity Hospital were built later followed by the Institute of Pathology.

The new buildings recently constructed are Lakeside Hospital, a private pavilion and the nurses' dormitory. Buildings planned for the future to complete the group are a school of nursing, a recreational building for the nurses, a staff house for the internes, and a service building, which will include a laundry. Various departmental buildings similar to that used by the pathological department also are contemplated.

Layout of the New Buildings

Lakeside Hospital is H-shaped, dividing the building into two wings and a stem. In the basement are an ice-making plant, pharmacy storage room, general lockers, storage rooms, the main kitchen, service dining room, general stores for the kitchen, generous refrigerating capacity, a dietetic kitchen, cooking laboratory, dietetic demonstration, light therapy, accident ward and section, pharmacy supplies, serving room and nursing classrooms.

On the first floor are general offices, the resident superintendent's suite, female interne quarters, the recording section and dispensaries. Private and semi-private rooms, solaria, nursing units, diet kitchen, a complete X-ray area, dispensaries, examining rooms and laboratories are on the second.

The third floor contains an isolation ward, special nursing quarters and diet kitchen, laboratories, offices, library and dispensary. More rooms for patients as well as diet kitchen, wards and laboratories are located on the fourth floor.

The fifth floor is devoted to surgery and professors' rooms. The first floor of the operating amphitheater is on this floor, continuing up to the sixth floor. Here students and visiting doctors watch operations being performed. On the seventh floor are rooms for visiting doctors, surgeons' dressing rooms, quarters for the chief surgeon and his secretary, surgical dressings, nurses' rooms and classrooms and anaesthesia rooms.

The eighth floor is in the stem of the building and contains the upper parts of the operating rooms. Here again provisions are made for the benefit of students and visiting doctors. Film storage, animal rooms, and supply fans are on the ninth. Recovery rooms and a fan room at either end complete this enormous hospital.

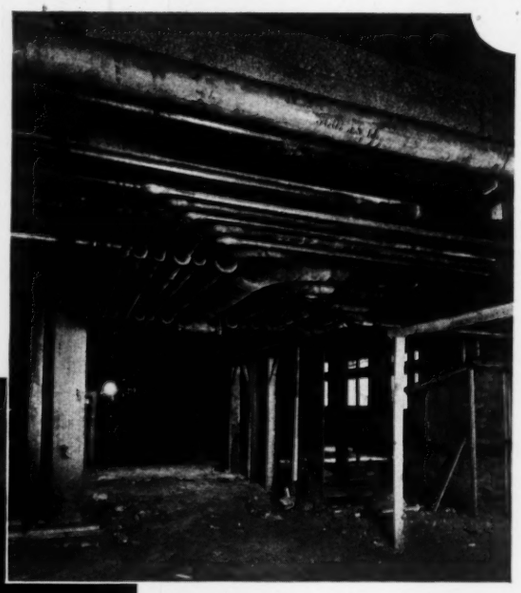
The Private Pavilion

The private pavilion, designed for patients wishing more privacy and a greater degree of luxury,

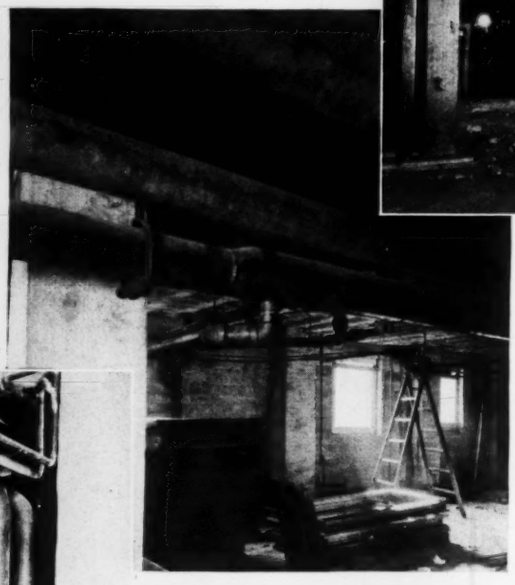
consists of six floors. This building has its own kitchen in the basement. The office, library and internes' quarters are located on the first floor, the surgery on the sixth floor and the remainder of the space is devoted to private and semi-private rooms for patients.

The Nurses' Dormitory

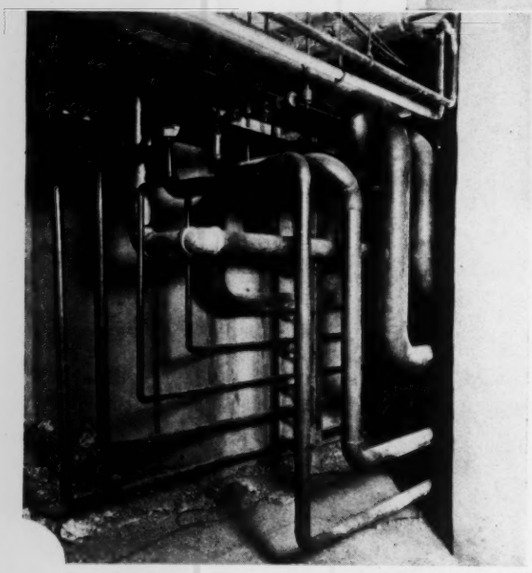
The nurses' dormitory is in the shape of a quadrangle, and is practically four separate buildings above the first story. There are a lobby, rooms for the hostess, men's room, small reception room and a small tea kitchen for each one. Four hundred nurses can be accommodated and there is a hospital area with beds for fifteen nurses. The basement is planned with a main kitchen and serving rooms so arranged that each of the four buildings has separate dining facilities. The upper floors contain a suite for the supervisor and individual rooms for the nurses in each of the four divisions. The dormitory is five stories high.



(Above) Special Elbows and the Bottom Layer of Mains in the Lakeside Hospital. Another Group of Mains Above Cannot Be Seen



An Interesting Study of the Use of Elbows at the Mouth of the Tunnel Leading from the Lakeside Hospital Subbasement to the Private Pavilion and the Nurses' Dormitory. The Lines for the Pavilion Are on the Left Hand and Those for the Dormitory on the Right



(Left) Note Swedging of the Steam Main. Photo Taken in Basement of the Nurses' Dormitory

Mechanical Problems in Hospitals

The designing of mechanical equipment for hospitals is beset by many problems. The desire for improved or recently developed equipment results in many changes in the plans. New ideas are brought forward by physicians as well as by engineers in the hope of approaching as nearly as possible to perfection. Each hospital is ambitious to use only the newest and the best. Ingenuity and ability are required to solve problems that result from such changes and there were plenty of such problems on this job.

Rooms on the third floor of Lakeside Hospital, originally planned for internes, and for that reason without any special ventilation, were converted into laboratories at the last moment. The large vertical duct spaces at each end of the building were already full and there was no room for another. The problem was finally solved by increasing the amount of air to be handled by enlarging the fans on the roof for ducts in those vertical spaces, and in that way increasing the velocity of the air in the ducts. The whole duct was then cut down in size, making room for additional ducts which had to be extended in corkscrew fashion around those already installed.

In like fashion, the pipes were twisted around existing pipes to take care of the laboratory needs. Medium pressure steam pipes were run through the outside wall on the ceiling to the floor above where they connect with the sterilizers. There were no mains for either the compressed air or vacuum and these had to be installed. These are typical of the problems that confront the engineer in hospital work. A seemingly unimportant alteration may make it necessary to re-design a whole floor.

The Heating

Steam for heating is generated in the power plant (enlarged to take care of the new buildings), which is 1,000 feet from the three new buildings. Steam pressure of 100 lb. is carried in the high pressure mains through the tunnels to each building. At the buildings it is reduced from 100 lb. to 60 lb. for the medium pressure work, then from 60 lb. to 2 lb. Following this pressure reducing valves reduce the steam to sub-atmospheric pressures for the heating system, providing steam at variable temperatures according to weather conditions. (From 153 F to 240 F.)

In the nurses' home, the steam is also reduced to sub-atmospheric pressure by sub-atmospheric pressure control valves. The condensate from the direct radiation is returned by the vacuum pumps to the power house at a pressure of forty pounds. There are 826 radiators with approximately 20,567 sq. ft. of radiation.

The hospital contains 1,252 radiators having a heating surface of approximately 45,000 sq. ft. The blast, heating load and hot water returns are handled by a vacuum pump. The medium pressure equipment of the hospital is handled by condensation pumps.

The third building in this new group, the private pavilion, contains 245 radiators with 8,681 sq. ft. of heating surface. It also is equipped with its own set of sub-atmospheric pressure control valves and pumps. The condensate from the blast, heating, and hot water is cared for by a vacuum pump.

Steam and return mains are welded throughout. Screwed fittings are used in the riser and radiator connections. The steam is supplied to the radiators by up-feed risers and the base of each riser is dripped into the return.

A complete system of compressed air, vacuum and medium pressure steam piping also is installed for laboratory purposes.

Fourteen carloads of radiators and seven carloads of pipe covering were used.

The Ventilating Equipment

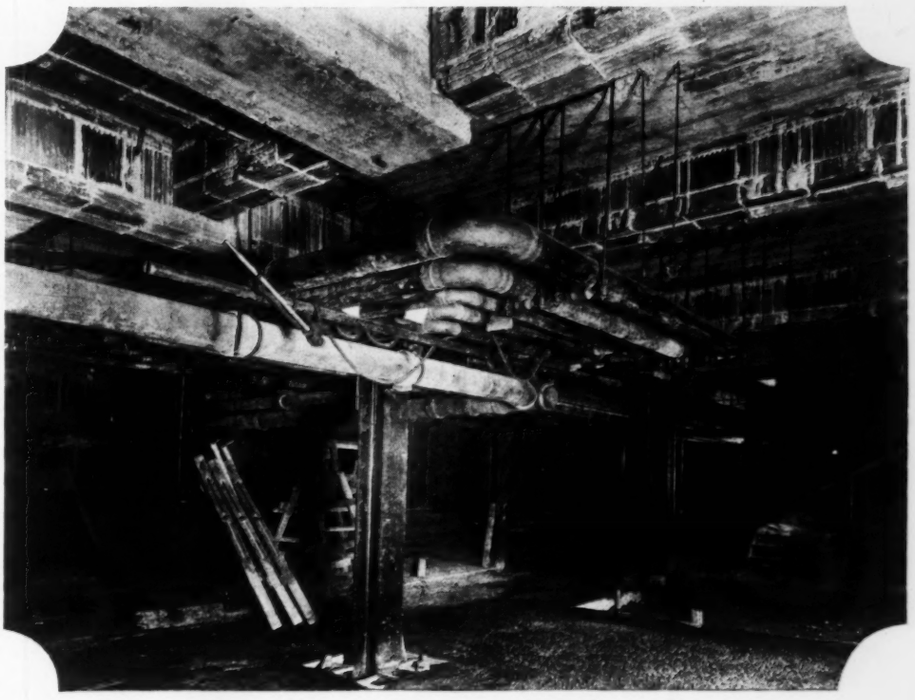
Thirty-four fans and motors are used in Lakeside Hospital, fifteen in the nurses' dormitory and eight in the private pavilion. The tendency, according to the engineers, Buerkel and Company, Inc., is for hospitals to subordinate ventilation to other considerations. Lack of money for mechanical equipment, the desire for equipment which physicians believe to be more necessary than ventilating equipment, and lack of definite physiological data on ventilation for hospitals, influence this tendency.

Hospital ventilation problems differ from those in an office building where many employes are in the same room. Even large hospital wards are so designed that each inmate is given a much larger individual air space than he would have in an office. The importance of air conditioning in hospitals, except for operating rooms and anesthetising rooms, is not agreed upon among engineers.

The air in these three buildings is heated, but not cooled, on the belief that cooled air might prove detrimental rather than helpful to the patients. No dehumidifiers are used.

All entering air is filtered through automatic, self-cleaning viscous filters. The metal filtering surface is stretched around two revolving drums, the lower being partially submerged in a bath of oil. A clock-operated electric motor revolves the drums once every twelve hours, carrying the dirty surface of the filter through the bath for cleansing and recoating, and moving a clean and newly-coated surface into the passage of the air to be cleansed.

Unit, water spray type humidifiers are installed in



EACH OF THESE LINES IS HUNG SEPARATELY BECAUSE OF THE LONG RUNS AND THE DIFFERENT STEAM PRESSURES VARYING THE EXPANSION OF THE DIFFERENT LINES

operating rooms and other rooms where anesthetics will be used, one to each room to be humidified.

The following table shows the cubic feet of air used in the hospital:—

	Total HP.	Cfm.
Lakeside Hospital		
2 supply fans	5	5,600
4 general vent fans	11	21,000
4 toilet vent fans	15	25,000
8 laboratory vent fans	15	21,000
1 operating vent fan	5	6,500
12 miscellaneous	6	7,500
3 kitchen vent fans	8	16,000
Private Pavilion		
1 supply fan	1	1,600
2 kitchen vent fans	2¼	4,000
1 toilet vent fan	5	9,500
1 operating vent fan	1½	3,500
3 miscellaneous	2	2,500
Nurses' Dormitory		
4 toilet vent fans	4	8,000
4 kitchen vent fans	6	9,000
4 laundry vent fans	2	2,000
3 miscellaneous	1½	1,600

The temperature of entering air in the winter is approximately 90 F leaving the fan heaters. The air enters the room near the ceiling and leaves the room near the floor and ceiling through hoods, toilet fixtures, etc., depending upon conditions. Vent fans discharge above the roof.

The fan motors are standard 1,200 r.p.m., driving the fans by means of multiple drives. In the new buildings the current is alternating 230 volt while in the power house it is direct current 230 volt. The fans are of the multiblade type. Static pressure ranges from seven-eighths of an inch on supply systems to one-eighth of an inch on the small exhaust fans. Extended surface, copper tube air heaters are used on the supply fans described.

Automatic temperature control has been used to temper the air in the amphitheaters in Lakeside Hospital. The valves on the main and the risers are manually-controlled.

Rust-resisting sheet metal is used on the duct work with the exceptions that lead coated ducts were used in the laboratories, painted special metal on the garbage room ducts, and sheet copper on the laundry vents. Stamped steel grilles were used throughout. The maximum velocity of air in the main ducts is 1,200 ft. per minute, and the average velocity leaving or entering the grilles is 300 ft. per minute.

Additions to Power Plant

The additions to the power house which complete the plant for the present project are two new boilers, a complete system of combustion control, one new laboratory vacuum pump, one new brine circulation pump for refrigeration, two new condenser water circulating pumps for refrigeration and one new ammonia condenser.

Refrigeration

The refrigeration plant is 120-ton capacity, comprising two 60-ton ammonia compressors. Brine is cooled in the main brine tank by means of ammonia, then pumped by electric-driven, centrifugal pumps through the tunnels to the several buildings, both old and new. Two brine pump motors, each 20 hp., and one 30 hp., pump are used. The main brine supply to the buildings is 8-in. The capacity required by Lakeside Hospital is seven tons; for the private pavilion, two tons; and for the nurses' dormitory, six tons. The compressors located in the power house are driven by two steam engines, each 100 hp.

In addition to the above there are numerous, isolated, small electric type refrigerators scattered throughout the buildings. No ammonia is used in the buildings themselves except in the power house, where it is used to cool calcium chloride brine which is then piped to the other buildings.

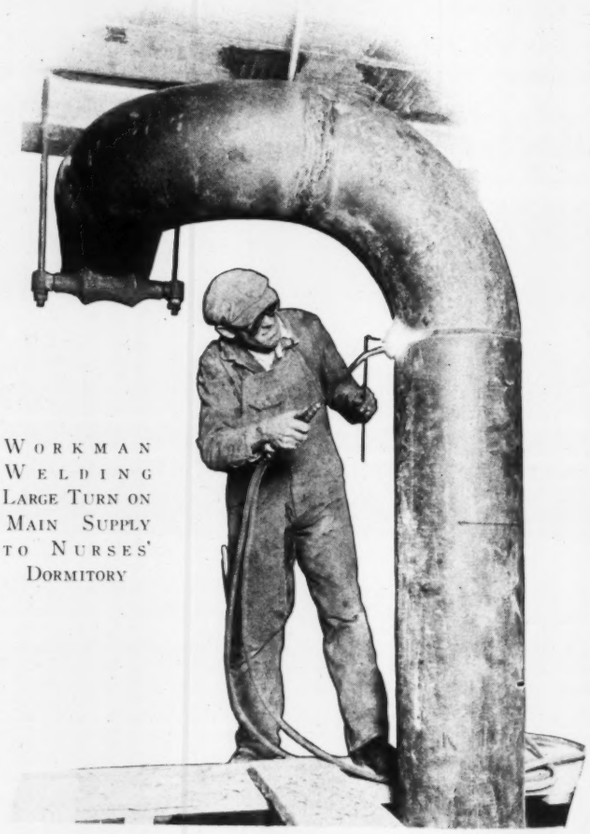
Due to the fact that the buildings are planned as a combination of school and hospital, the cost per cubic foot per occupant may prove much higher than for the usual hospital buildings. At the present time, such figures are not available.

Following is a table showing the floor area, cubic foot measurements and cost of each building. The cost includes the tunnels which are not included in the other two figures.

	Floor Area sq. ft.	Total cu. ft.	Cost
Lakeside Hospital	275,176	3,893,000	$2,805,000
Private Pavilion	50,069	742,000	690,000
Nurses' Dormitory	156,076	1,830,000	1,350,000

The entire building program for the three buildings described herein runs to $4,845,000 in what is the most important group of hospitals in this part of the country.

Buerkel & Co., Inc., Boston, were the designing engineers and W. B. Van Sickle Co., Cleveland, Ohio, the heating and ventilating contractors.



Workman Welding Large Turn on Main Supply to Nurses' Dormitory

Canadian Cold Storage Plant Uses Quick Freezing

By Albert E. Macdonald

REQUIRING a little more than a year in the process of construction, the cold storage plant at the Halifax Ocean Terminals, operated by the Nova Scotia Public Cold Storage Terminals, Limited, and erected at a cost of approximately two and one-quarter million dollars, was formally opened in the latter part of 1929.

The storage and other services that the plant provides may be enjoyed by the smallest as well as the largest dealer. The company does not buy commodities. Other than the making of ice to sell to fishermen and fish merchants and also to ice refrigeration cars, the company limits itself to supplying air-conditioned dry and cold storage on moderate terms.

Cold Storage Plant

The cold storage plant is made up of the following units:

1. General cold storage.
2. Apple and potato pre-cooling and storage.
3. Fish processing and cold storage.
4. Ice storage.
5. Ice making plant.
6. Power plant.
7. Fish landing building and stores.
8. Pier.

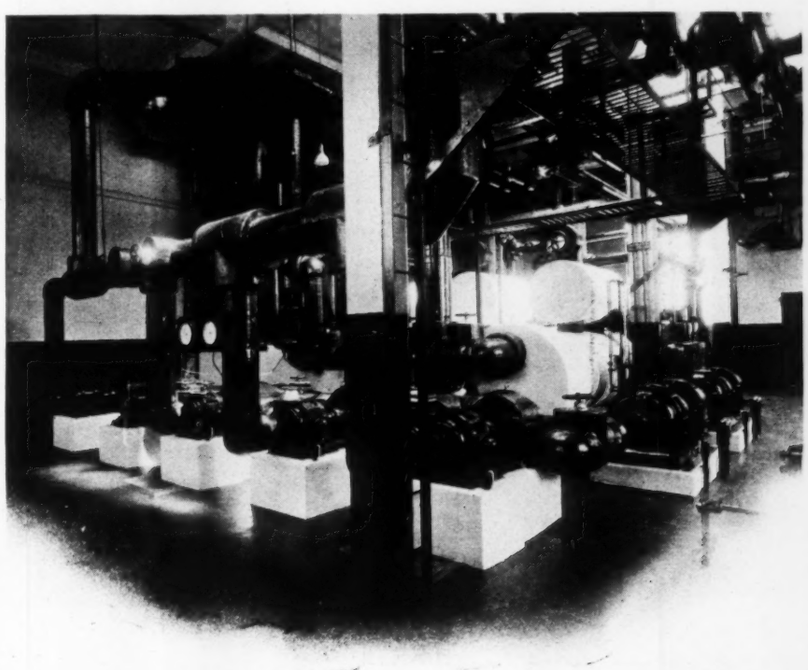
The first three of these units, due to their size and use, lend themselves well to drop-panel flat-slab construction. Supporting beams in the power plant are steel sections and side walls of the fish landing building are of brick, otherwise the plant is wholly of reinforced concrete, insulated where necessary with corkboard insulation and supported on a foundation of solid rock, which is close to the surface at the site of the plant.

The general cold storage for eggs, butter, cheese, veal, lamb, mutton, beef and vegetables consists of six stories.

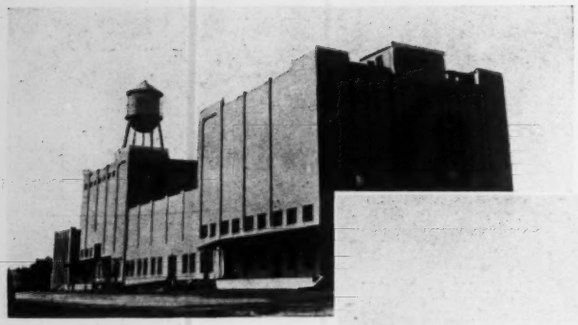
The first floor of this building is for shipping and receiving. The second floor is for dry storage, candling of eggs, cutting butter, etc. The third and fourth floors are coolers; temperature 25 to 45 F, and the fifth and sixth are freezers; temperature—10 F to 25 F.

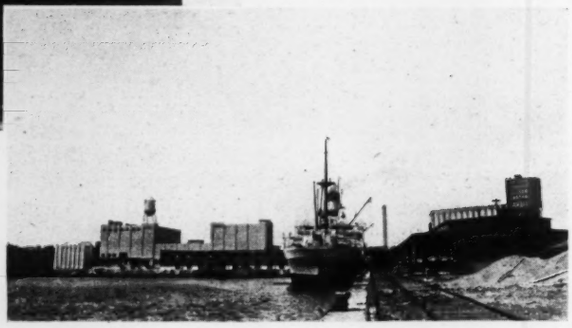
On the second floor are a few offices available for rental to produce dealers and others using the company's service. One office is donated to the school of fisheries, Dalhousie University, for research work.

The apple and potato warehouse consists of three floors. The shipping floor is equipped with two interior sidings with a capacity of three cars each and two elevators of 3 tons capacity each. The basement is used for storing potatoes and is served by the elevators, and hatches in the floor. The general offices of the company are located on the shipping floor in the front of the building.



NOVA SCOTIA PUBLIC COLD STORAGE TERMINALS, LIMITED. INTERIOR OF POWER PLANT SHOWING COOLERS AND PIPING





ABOVE—FRONT VIEW N. S. PUBLIC COLD STORAGE TERMINALS, LTD.

VIEW FROM WATERFRONT

A temperature of 35 F can be maintained in this warehouse by circulating air previously passed over cooler coils through ducts with which the storage floors are equipped.

The fish processing and cold storage warehouse consists of six floors, with a total refrigeration space of 475,000 cu. ft.

The first floor is for shipping and receiving. On the second floor is the fish processing and brine freezing equipment. On the third floor is sharp freezing and frozen storage, and on the fourth and fifth is frozen storage. On the sixth floor is dry storage for salt and pickled fish and general products not requiring refrigerated space.

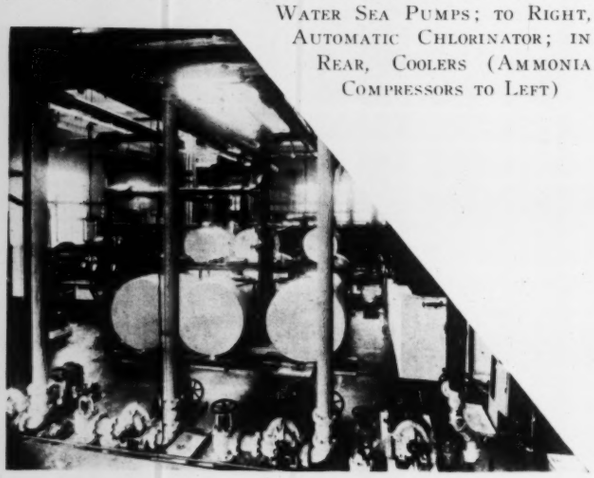
These three units so far described adjoin one another to form one large building. The ice storage, ice plant and power plant form one building also, although they are three distinct units in themselves.

The ice storage is insulated with corkboard and has a capacity of 1,000 tons.

Fifty Tons of Ice Daily

In the ice plant, cans are filled with fresh water from the city service, a nest of 12 being deposited in the brine tank at one time by means of a 2-ton electric crane. After freezing for 16 hours they are lifted, dipped in a small water tank to loosen the blocks, and then tipped on the concrete floor by means of a special rack. This ice plant, which has a daily capacity of 50 tons, is also equipped with two ice crushers which crush blocks into proper size for use aboard trawlers and for packing fresh fish to be shipped unfrozen. A vertical conveyor carries the crushed ice to a spout fixed outside the building, which in turn delivers it to a truck or similar conveyance.

INTERIOR OF POWER PLANT, SHOWING, IN FOREGROUND, SALT WATER SEA PUMPS; TO RIGHT, AUTOMATIC CHLORINATOR; IN REAR, COOLERS (AMMONIA COMPRESSORS TO LEFT)



Power Plant Equipment

The power plant has a capacity of 550 tons of refrigeration per 24 hours. All machinery is electrically driven from the high tension power supply of 22,000 volts. Of a total of 1,800 hp. in the cold storage, about 1,600 is in the power house. Five ammonia compressors supply the refrigeration for the cold storage and are ideally designed to give the best possible flexibility. Brine pipes, heavily insulated, carry cold brine (30 per cent calcium chloride mixed with water from the city supply) from the power house to the various rooms throughout the plant.

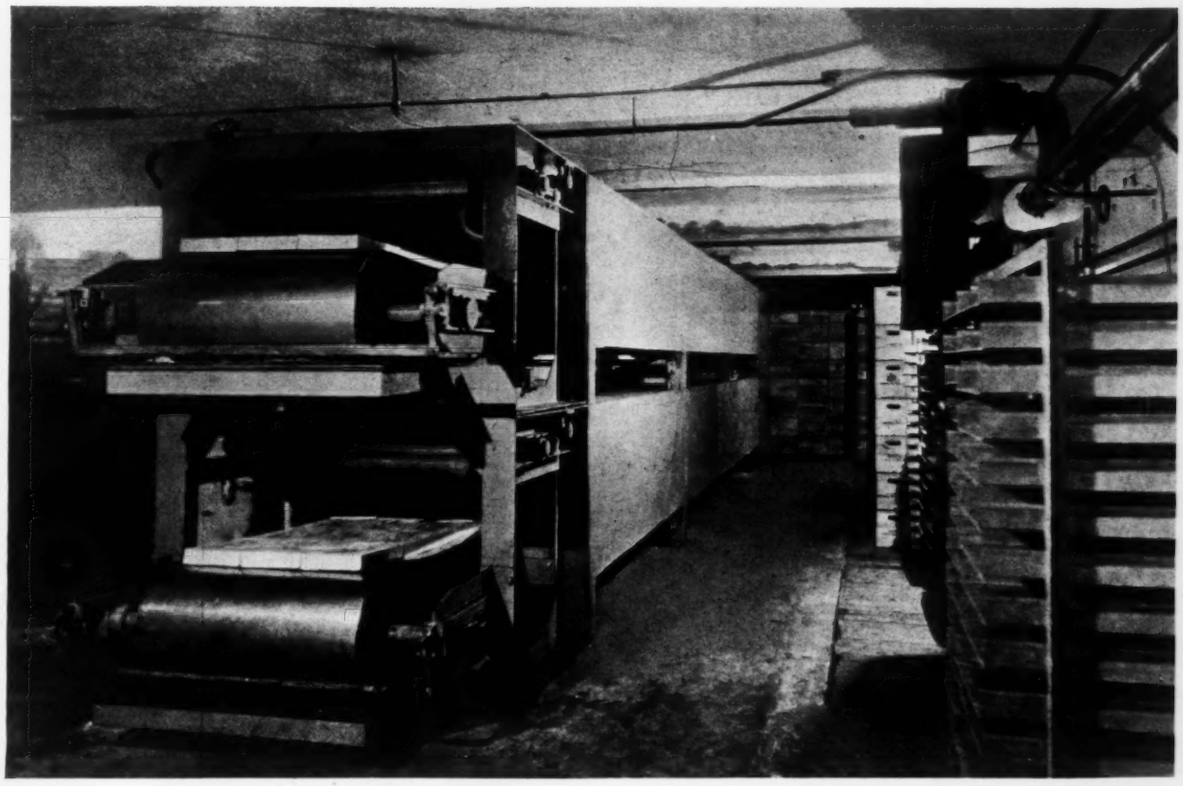
Salt sea pumps bring in sea water from an intake in the harbor at a location 10 ft. below the surface at low tide. This water is treated with chlorine gas by means of a chlorinator and is used in washing fish and flushing floors. The solution is harmless, but is an effective sterilizer.

The fish landing building is 50 ft. × 200 ft. two stories high and is divided into four stores 50 ft. × 50 ft. each.

Facilities Offered Fishing Industry

The fish processing and cold storage building provides the following facilities to the fishing industry:

1. Reception coolers for temporary holding of fresh fish pending processing.
2. Filleting and skinning service.
3. Panning service for mackerel, herring, etc.
4. Packing room where fillets can be packed before or after freezing, as desired.
5. Brine freezing equipment.
6. Sharp freezers for whole fish such as mackerel, salmon, herring, etc.
7. Bait freezing.
8. Storage for frozen fish.
9. Storage and shipping facilities for dried and pickled fish.



THE FREEZING EQUIPMENT, WHICH CONSISTS OF TWO FREEZING UNITS, ONE ABOVE THE OTHER. WITH THIS PROCESS, THE PRODUCT TO BE FROZEN IS FED ON THE RECEIVING END OF THE LOWER BELT AND PASSES INTO THE INSULATED TUNNEL UNDER ANOTHER METAL BELT. WHILE THE FISH ARE PASSING THROUGH THE TUNNEL, CALCIUM CHLORIDE BRINE IS SPRAYED ON THE UPPER SIDE OF THE UPPER BELT AND THE LOWER SIDE OF THE BOTTOM BELT. THE BRINE IS NORMALLY KEPT AT ABOUT 45 F AND WHEN THE FILLETS EMERGE FROM THE TUNNEL THEY ARE FROZEN STONE HARD. IN THIS SYSTEM OF RAPID FREEZING, CONDUCTION IS OBTAINED ON BOTH THE LOWER AND UPPER SIDES OF THE FILLETS

Fish Processing Procedure

The second story of the fish warehouse is known as the fish processing floor and is laid out entirely for fish processing. The floor is waterproof and is continually flushed with chlorinated sea water to keep it clean and free from bacteria. Here is located a portable scaler which takes the place of about six men, also a skinner capable of skinning any size of fillet, with a capacity of 30 fillets per minute. Whole fish washing tanks, conveyors, cutting tables, a briner containing a solution of salt brine and chlorine to wash and sterilize fish fillets prior to being wrapped and frozen, are also located on this floor.

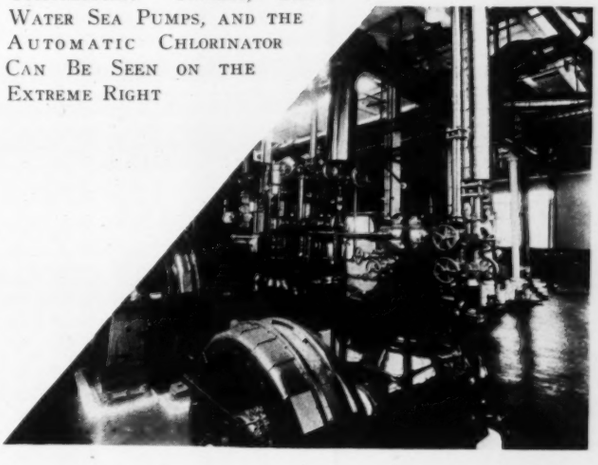
In the packing room fillets are wrapped in waterproof paper, weighed into cartons or boxes of unit size, and are then placed in racks ready to be taken to the brine freezer.

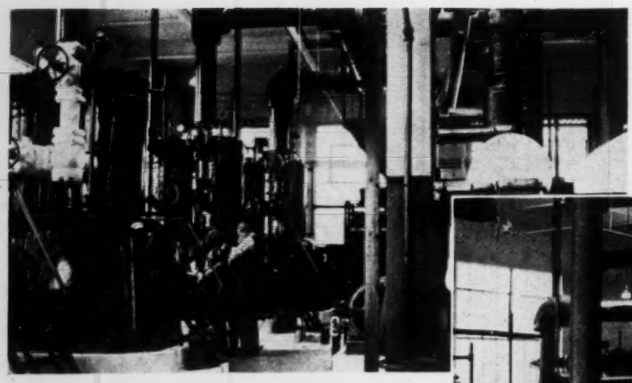
After freezing, the packages are placed in a holding room for a few hours at a temperature of —5 F to equalize the temperature through the carton. They are then either shipped or sent upstairs for storage.

Glazing tanks prevent the evaporation of juices in fish while in storage.

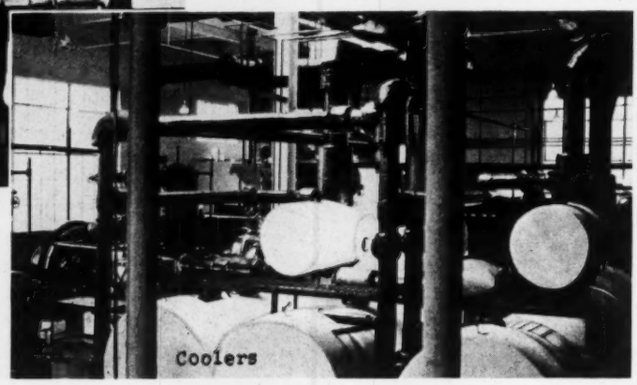
Nova Scotia Public Cold Storage Terminals, Ltd., has exclusive control of a freezing process, the essential parts of which are two monel metal, horizontal, continuous belts. These conveyors are enclosed in a compartment and placed one above the other, the upper conveyor having the wider belt. The belts are cooled by having the two surfaces adjacent, those in contact with the box or carton, sprayed with calcium chloride brine at 45 F below zero. The upper belt automatically adjusts itself so that a box may pass between the belts without crushing. The belts may be stopped for any length of time allowing the box to remain long enough in contact with the cold for the contents to be frozen, after which

INTERIOR OF POWER PLANT SHOWING THE FIVE AMMONIA COMPRESSORS. COOLERS, SALT WATER SEA PUMPS, AND THE AUTOMATIC CHLORINATOR CAN BE SEEN ON THE EXTREME RIGHT





THE COMPRESSORS AND THE COOLERS



it is delivered at the other end of the machine. The box is then placed in storage or shipped in refrigeration cars and sold to the consumer from cold storage show cases.

This machine is used in freezing foodstuffs up to a thickness of 9 inches, the time of freezing depending upon the thickness of the article. Single fillets can be frozen in 9 minutes.

Strawberries in Winter

Strawberries, raspberries and blueberries, and all types of fish, are treated in a similar manner for brine freezing. The consumer, in addition to being able to obtain strictly fresh fish at all times of the year by means of this process, will also be able to procure, during the winter, berries that are just as fresh and delicious as those bought in season. Formerly, it was necessary to pick the fruit green and allow it to ripen in transit. Loss often was sustained through bruising or spoiling of the fruit.

The pre-cooling facilities of the plant will permit the apple growers to tree-ripen their fruits and ship them to the cold storage warehouse where they will be air-cooled, repacked if necessary in suitable containers, and then either stored for future consumption or shipped.

The general cold storage building, apple and potato building, and fish cold storage building possess an efficient sprinkler system. A 40,000-gallon capacity tank, on top of the latter building, provides the necessary head for the system. The liquid used is calcium chloride brine to prevent freezing of the sprinkler pipes in the cold rooms.

In the basement is located the mixing tank to which the brine in the sprinkler pipes may be drained, and here also is the pump for filling the tank on the roof.

Welding Carbonic Acid Pipe

Carbonic acid pipe has to stand about 1,200 pounds working pressure and should be tested to about 3,000 pounds and hence must be extra heavy throughout up to 8 in. diameter. Above that it should be double extra heavy, but, of course, that is necessarily applied only to receivers or air chambers and not to regular pipe lines, as no joints have been made requiring such large dimensions.

A practice used widely is to weld all pipes by either acetylene or electric welding process, bending pipes for elbows. In welding it is difficult to weld two articles of different thickness or weight because they do not heat evenly. It is very difficult to weld a nipple or pipe to a valve because the valve body is heavy. Furthermore, in heating the valve to a red heat, at the ends the heat extends into the center and is very apt to warp the seat; hence, great care must be used. A very good plan of welding fittings is to turn the fitting down until the edge is about the thickness of the pipe that is to be welded to it.

In case of a V-weld, the pipe should be slightly separated and the fusible metal run down to the very bottom of the V. Workmen should be cautioned and should be very careful to have the weld go all the way through. Such a weld cannot be examined on the inside and after it is done there is no good means of telling whether the weld runs through. Therefore, none but conscientious workmen should do this work and, of course, the piping should be tested so as to stand a good margin of safety.

Tees can often be cut into the pipe, but the piping should be of ample size to carry the gases at a reasonable velocity. Remember that carbonic acid gas under the discharge pressure is about half the weight of water; hence, it is a very heavy substance and cannot flow with the same velocities at which light gases can be handled.

Running Pipes

The piping should be true and plumb, properly supported, and it should be remembered that this heavy liquid gives quite a vibration in reaction at each elbow where the direction of the flow is changed, producing considerable thrust which must be handled properly by a brace to the column.

Carbonic acid has little action on piping, is generally pretty dry, with very little rusting up effect, and therefore the joints have to be made very perfectly at the start in order to insure tightness.—*Henry Torrance.*

"Open for Discussion"

A department in which we follow the custom of technical societies of allotting space in their programs for discussion of the papers presented

Computing Radiation

"Calculating Radiation Requirements," *by W. R. Woolrich and L. Holdredge.* Page 291, April, 1930

I HAVE read the article, "Calculating Radiation Requirements," by W. R. Woolrich and L. Holdredge in the April issue of HEATING, PIPING AND AIR CONDITIONING and, while I do not want to appear too critical, I cannot help but feel that the article is both obsolete and misleading.

I say that most of the material in the article is obsolete for two reasons, namely:

(a) Figs. 1 to 14 inclusive, and much of the text, refer to a type of radiator that is no longer on the market and has not been on the market for three years or more.

(b) For three years or more, a square foot of radiation has been defined as "that surface which emits 240 Btu per hour when the steam temperature is 215 F and the room temperature is 70." Except in the case of wall radiation, all radiator manufacturers now rate their radiators on the above mentioned standard basis and consequently Figs. 1 to 14 inclusive are not only useless but misleading, because someone may try to apply them to up-to-date radiation.

The tables which evidently were the basis of the author's graphs last appeared in the 1928 *Guide* of the *A. S. H. V. E.* and these tables were practically obsolete the last time they were published.

In making their various comparisons of calculating methods, the authors make no mention of the "infiltration method" of obtaining the radiation required to heat up the incoming air. This method, which has been advocated by the *A. S. H. V. E.* for years, is the only method having a scientific background and every student of heating and ventilating should be taught how to use it.

Heat from Occupants

The authors make an error at the top of page 296 which is not scientifically sound and which will often lead to absurd results. After obtaining the heat loss of the room, the authors subtract the body heat given off by the occupants and then select radiation to make up the difference. Such procedure can only be justified where a room has full occupancy 24 hours a day.

Imagine the effect of such procedure in calculating the radiation required in a school room. On coldest days, the youngsters would have to arrive at least a half hour early and sit with their overcoats on until their bodies supplied the heat called for by the author's method of calculation.

Take another example. The new field house which is being built on the University of Wisconsin campus has a heat loss slightly less than 4,800,000 Btu per hour when the inside temperature is 70 F and the outside temperature is —15. The building will have a seating capacity of 12,000 people. A rabid basketball fan will easily emit 400 Btu per hour and 12,000 of them will emit 400×12,000 or 4,800,000 Btu per hour.

To follow the method of radiation calculation set forth by Woolrich and Holdredge leads to the result that one will not need a heating system in this field house. You can rest assured, however, that they are installing a heating system that will have the interior of the building up to 70 F before the crowd arrives and a ventilating system that will carry away the body heat when that source of heat exceeds the heat loss of the building.—*G. L. Larson,* Chairman, Dept. of Mechanical Engineering, University of Wisconsin.

The Authors' Answer

We have read the criticism of our article, "Calculating Radiation Requirements," with considerable interest.

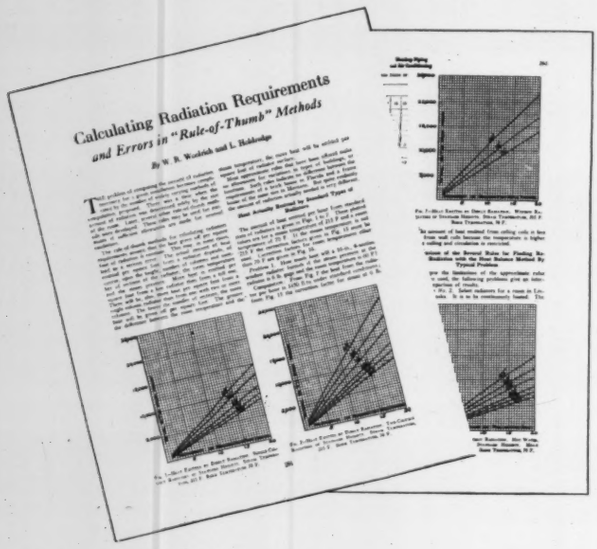
Prof. Larson is correct in his assumption that Figs. 1 to 14 refer to the column type of radiation. That fact is plainly stated under each figure. He is very greatly in error in thinking that since the tube type of radiation is on the market, engineers will have no need of the older data. Of course, new radiation will be of the tube type, but in many cases, such as remodelling, the engineer and architect must deal with the column radiation. At least 90 per cent of the present installed radiation is of the column type. If the tables are no longer published the graphs will be of more value than ever, when any of the old radiation is used. He should note, however, that the tables are still published in condensed form in the 1929 edition of the *Guide* and are found on page 68.

He says, "A square foot of radiation has been defined as 'that surface which emits 240 Btu per hour when the steam temperature is 215 F and the room temperature is 70 F. Except in the case of wall radiation, all radiator manufacturers now rate their radiators on the above mentioned basis.'"

Under date of January 18, 1930 one of the largest manufacturers wrote us: "In other words, they emit 240 Btu per hour per square foot with room temperature 70 F and steam at 2 lb. pressure." Steam temperature at two lb. gage will depend on the barometer, but in most parts of the United States with average barometer the temperature will be about 218 F.

The 1929 edition of the *Guide* under the heading, *Total Heat Emission of Cast Iron Radiators,* says: "Tube radiators are not yet standardized, and it is,

therefore, impossible to give standard data." Under the same heading we also find, "However, sufficient radiation is being calculated on the old basis to warrant the inclusion of a condensed table of heat emission based on the actual number of square feet of


Calculating Radiation Requirements
and Errors in "Rule-of-Thumb" Methods

surface presented by various types of column radiators."

Reference to the catalogs of radiator manufacturers shows that the rated surface in any case is the "surface" per section, times the number of sections. Everyone knows that a ten-section radiator of a given height and number of tubes does not emit five times as much heat as a two-section radiator, yet it is rated at five times as much surface. The actual amount of heat per section depends upon the number of sections. The column type of radiator shows an emission of from 50 per cent to 60 per cent more on the end sections than on the intermediate sections.

Heat Balance Method Should Be Used

But all this is beside the real point. Our main contention was that radiation should be calculated on the heat balance method. We used several methods that have been extensively used and compared them with the heat balance method and showed that the heat balance method is the only safe method to use under all conditions. In this, we quite naturally used the radiation whose heat emission is well-established. Whether the radiation is of the old column type or of the new tube type, the heat balance method is still the only safe way to calculate radiation.

In regard to the incoming air, we stated that three changes of air per hour were required. That is 30 c.f.m. per person for the assumed conditions. Part of this air will be by natural leakage and the remainder supplied by some method of ventilation. The "infiltration method" may be used to find the amount of air which leaks into the room, but we do not state whether we use it or not, simply because, for our discussion, we are interested in the total amount of air to be heated. Obviously the "infiltrated" air is less than the total air required with a room full of people.

In his criticism of our method of finding the total heat needed and subtracting the heat furnished by sources of heat other than the heating system, our critic makes two serious errors:

(a) He attempts to apply an equation for continuous heating to a job of intermittent heating.

(b) He entirely ignores the air required for ventilation.

In the two cases mentioned he reaches the wrong conclusions because he did *not* follow our method; and not because he did.

The average school room will require about nine changes of air per hour to supply 30 c.f.m. per person as required by the standards of the *A. S. H. V. E.* and the laws of several states, according to the 1929 *Guide*. The amount of infiltrated air will be about one-tenth of this for well constructed buildings with the windows weather stripped, to one-third with poorly constructed buildings.

Take the case of a poorly constructed building. While the children are in the room twenty cubic feet of air per minute per person much be supplied above that which leaks in with the building, either occupied or unoccupied. If there are 30 children in the room, this will mean that we must raise $30 \times 20 \times 60$ feet of air per hour from the outside temperature to the room temperature. Suppose the outside temperature is 0 F. Then we must heat $30 \times 20 \times 60$ cubic feet of air from 0 F to 70 F. This will require about 46,000 Btu per hr. The heat given off by the children will amount only to about 300 Btu per hr. for each child. This is 300×30, or 9,000 Btu per hr. 37,000 more Btu per hr. are needed with the room occupied than with it unoccupied. This is for a very poorly constructed building.

For good construction the difference will be more than that. So our critic's conclusion that the children would have to sit with their overcoats on until the room was warmed up is incorrect, and any such failure to remember that the air needed for ventilation must be warmed to room temperature appears ridiculous to us.

Consider the field house at the University of Wisconsin. Prof. Larson does not give the figures as to the amount of infiltrated air, but let us assume that it represents one-half of the heat loss with the building unoccupied. It takes approximately 1.6 Btu to heat one cubic foot of air from —15 F to 70 F. One-half of 4,800,000 is 2,400,000. 2,400,000 divided by 1.6 is 1,500,000. This is slightly over two cubic feet per person per minute. Let us now assume that only one-fourth of the standard amount of air is supplied. This will be 7½ c.f.m. per person; or $7\frac{1}{2} \times 12{,}000 \times 60 = 5{,}400{,}000$ cubic feet per hour. To raise this from —15 F to 70 F requires $5{,}400{,}000 \times 1.6$ or 8,640,000 Btu per hr. Now add to this 2,400,000 and we have the total amount of heat required per hr. This is 11,104,000 Btu. But the people emit 4,800,000 Btu, leaving a total of 6,240,000 to be supplied by the heating system when the building is occupied. That lacks considerable of being zero.

He does not reach his conclusion by following the heat balance method, but by failing to follow it.

This failure to take into account the heat required for ventilation is a mistake.

Of course, our article does not pretend to cover every possible case of heating but the heat balance method, which we recommend, will cover every case. If a person leaves out his largest demand for heat and obtains an incorrect conclusion, the fault is not with the method.

In general, the maximum demand for heat will be with the building occupied, if proper ventilation is furnished. In any case we select radiation to emit sufficient heat at the maximum demand, but we still should use the heat balance method, as we showed in the article that other methods might lead to serious error.

In regard to the heating of school rooms, it is often true that they are frequently cool in the morning. We have found, in practically every case investigated, that this is due to poor design, poor operation, or lack of boiler capacity, and not to insufficient radiation.

This is one of a series of articles and a later one dealing with the elements of the heating system is the proper place to discuss the types of radiators. —*W. R. Woolrich,* Professor, Mechanical Engineering, and *Leo Holdredge,* Instructor, Mechanical Engineering, University of Tennessee.

Prof. Larson's Second Letter

My criticism in my first letter can be grouped under two headings:

1. That Figs. 1 to 14 inclusive, and much of the text of the article referred to a type of radiation that is no longer being manufactured and that, therefore, the information is of very little value to readers who are seeking information regarding the calculation of the present day tube radiation.
2. That it is not scientifically sound and will often lead to absurd results to subtract from the heat loss of rooms the body heat given off by occupants, and then select just enough radiation or other heat supply elements to make up the difference.

In answering criticism No. 1, the authors point out the fact that at least 90 per cent of the present *installed* radiation is of the column type. Granted, but I was under the impression that the article, "Calculating Radiation Requirements," was intended for present designers.

It is safe to say that 95 per cent of the radiation being *calculated* today is either tube or non-ferrous type of radiation. On the other hand, the radiation around which the authors build their paper has not been manufactured since 1926, and therefore is adaptable to less than 5 per cent of the radiation that is being calculated today.

Unit of Heat Output

The 1930 *Guide* has the following to say regarding the unit of heat output:

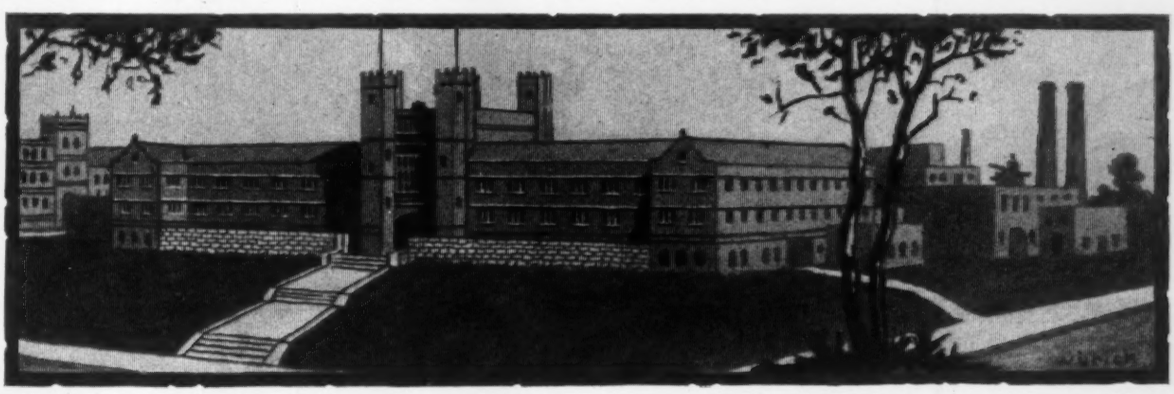
"In the past, the unit recognized in computing heat emission of radiators was the square foot of heating surface. The use of this unit is being discarded rapidly, however, for the reason that heat emission depends upon the design of the heater as well as upon the surface area. The engineer is interested primarily in the amount of heat emitted by, rather than the amount of surface in, a heat transferring agent. As a result, heaters are now rated on the heat given off either in Btu per hr. or in equivalent square feet, based on 240 Btu per hr., and there is a growing demand for some sort of new measure that will express also the room comfort effect of the heater."

It might also be added that the *A. S. H. V. E.* code accepts 215 degrees and 70 degrees, respectively, as standard steam and room temperatures, and of course proper corrections should be made if the operating conditions are much different from this.

It is, of course, well known to all who have had experience in radiator testing that end sections of a radiator emit more heat than intermediate sections. The authors are correct in their statement that this fact is not taken care of in the present manufacturers' catalogs.

It is true that end sections show a heat emission of from 50 per cent to 60 per cent more than intermediate sections, but the effect of this on the choice of radiation is more academic than real.

The increased heat emission of end sections is equivalent to less than one radiator section and the smallest unit that a designer can deal with is one radiator section. The designer will choose the number of sections that most nearly conforms with his calculated heat loss, whether he divides his heat loss by the heat emission of a square foot of radiation or uses total radiator heat emission tables. As a matter of fact, most designers will play safe and select the number of sections that will give him a heat emission nearest above his calculated value.



A number of years ago when we were calculating column radiation, I checked both methods on a number of buildings I was working on and found practically no difference in the total radiation obtained.

From a practical point of view, therefore, very little error results in neglecting the greater heat emission of end sections and whatever error there is on the side of safe design.

The Heat Balance Method

Now let us turn our attention to criticism No. 2. I agree with the authors that the method which they call the "heat balance" method is the only safe method to use under all conditions. We have used it in our design work for many years and it has been advocated by the *A. S. H. V. E.* for many years.

The only thing new about it as far as the authors are concerned is the name they have applied to it. It is more commonly known as the "Btu method."

I must confess that I find it difficult to follow the logic used by the authors in their letter in trying to justify the subtraction of the heat emission of occupants before selecting the capacity of the heating equipment. Apparently, they fail to differentiate between a heating plant and a ventilating plant. I believe that it is pretty generally understood that a plant that is capable of heating the ventilating air up to 70 F only is a ventilating plant and not a heating plant. It has no capacity whatever of supplying the heat losses of a building when that building is being maintained at a temperature of 70 F.

However, the authors maintain that my criticism is unjustified because they say I ignore the air required for ventilating. I have again read their original paper over carefully and fail to find any mention of a ventilating system in their discussion as to how radiation should be calculated. The authors state—"This failure to take into account the heat required for ventilation is where he makes a mistake."

I maintain that it is just as wrong to subtract the heat emission of the occupants where a ventilating system is involved as it is where no ventilation is used.

To illustrate this, let us again use the field house as an example. The heat loss of the building is 4,800,000 Btu per hr, when the interior temperature is 70 F and the temperature outside is 15 below zero. The heat emission of 12,000 people at 400 Btu per person per hr. would be 4,800,000 Btu. The authors subtract the heat emission of the occupants from the heat loss of the building and then design a heating plant to supply the difference. In this particular case, such procedure eliminates the heating plant, leaving a plant only sufficient to heat the ventilating air up to 70 F. Is this sufficient to have the building up to 70 F before the occupants arrive?

Let us assume the 10 cubic feet of 70 F air per person per minute must be heated up from —15 for ventilating purposes. (The authors use about 9½ c.f.m. in their letter.) Let T be the maximum temperature to which the interior of the building can be raised by the ventilating air and let us further assume that the heat loss of the building varies directly as the temperature gradient between the inside and outside temperatures. The weight of a cubic foot of 70 F air is .075 lb. and the specific heat of air is 0.24.

We can now set up the following equation, the left hand member of which represents the heat given up by the ventilating air and the right hand member the heat lost by the building. At some definite inside temperature, the heat given up by the ventilating air will exactly equal the heat lost from the building and we get a condition of equilibrium. What is that temperature in this case?

$$10 \times 12000 \times 60 \times .075 \times .24\ (70 - T) = 4{,}800{,}000\ \frac{(T + 15)}{85}$$

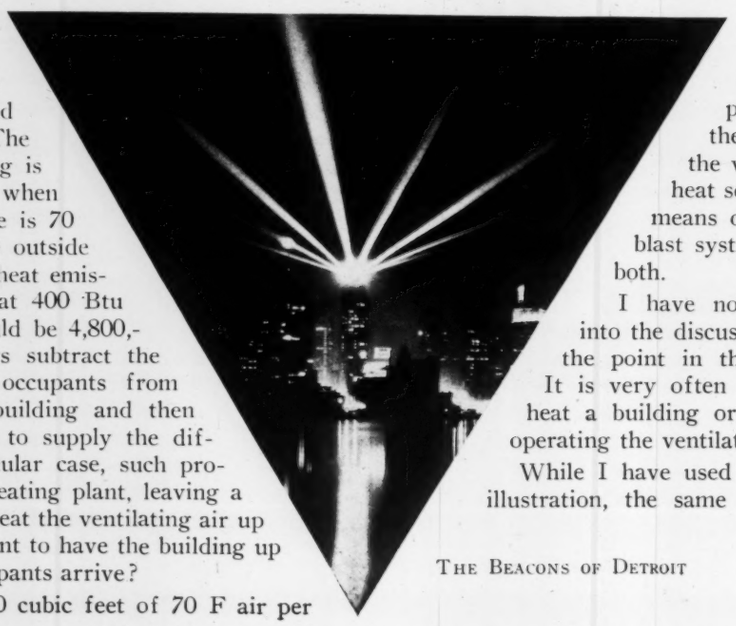
Solving this equation for T, we find that the ventilating system alone can heat the building up to only 44 F, when the ventilating air enters at 70 F. Therefore, we must have some other source of heat in addition to the ventilating system. Obviously, we cannot depend on the crowd to raise the temperature the additional 26 deg. because we must have the building up to 70 F before the crowd arrives, and furthermore, in many ventilated buildings the number of occupants may vary from 10 per cent to 100 per cent from day to day.

Look closely at both sides of the equation again. It is perfectly evident that a source of heat in addition to the ventilation requirements must be provided. As T approaches 70 F, the capacity of the ventilating system to supply heat approaches zero and the heat demand of the building approaches a maximum. At an interior temperature of 69 F, for instance, the ventilating system is capable of supplying less than 3 per cent of the heat loss of the building. The other 97 per cent or more must be supplied by the additional source.

In other words, a heat source equivalent to the heat loss of the building must be provided over and above the heat requirements of the ventilating system. This heat source can be provided by means of a split system, a full blast system or a combination of both.

I have not brought recirculation into the discussion because it is beside the point in this particular argument. It is very often desirable to be able to heat a building or certain rooms without operating the ventilating system.

While I have used the field house for my illustration, the same arguments and conclu-



The Beacons of Detroit

sions apply in a lesser degree to the school room mentioned in my previous letter.

In their letter, I note that the authors subtract from the ventilating requirements the estimated air that leaks into a building by infiltration. I know of no ventilating code that will allow such a procedure.

In closing, I wish to repeat that, in my opinion, the authors are wrong in subtracting the heat emission of the occupants from the calculated heat losses of rooms before selecting the capacity of the heating equipment. I think I have conclusively shown that such procedure is unsound and leads often to absurd results.

I also believe I have shown that it is the authors who have erred in applying their "heat balance" method to such buildings as the field house. They have completely "balanced" out the heating system and leave nothing but the ventilating system to carry the load.

While the field house has been used as an illustration, the same conclusions apply to a great majority of buildings such as schools, office buildings, theaters, etc.—*G. L. Larson.*

The Author's Second Letter

I want to express my appreciation for Professor Larson's comments. We are both evidently agreed but had different problems in mind.

During the past season I have checked sixty thousand square feet of old heating in addition to some forty thousand square feet of new heating. Naturally, I am interested in both old and new work. Professor Larson's pleasure seems to be new work, and he probably feels justified in looking upon a radiator of two years' standing as being antiquated.—*W. R. Woolrich.*

Flow of Fluids

"Ammonia Pipe Sizes," *by R. C. Doremus.* Page 287, April, 1930

THE writers wish to comment on the article entitled "Ammonia Pipe Sizes," by R. C. Doremus, printed in your April, 1930, issue. We would like to call Mr. Doremus' attention to an article in the February, 1930, issue of your magazine, "The Flow of Superheated Ammonia in One-inch Extra Heavy Black Steel Pipe," prepared by the writers.

Mr. Doremus states that there is a need for information concerning the flow of ammonia in order to design ammonia pipe lines more economically. Also, he points out the necessity for extended data concerning larger pipe sizes.

The writers, previous to their experimental work with superheated ammonia, realized the need of a criterion for a more economical choice of pipe sizes for ammonia lines. In determining the method for finding such a criterion, it seemed by far the best to analyze the flow of superheated ammonia upon the friction factor, Reynolds' number basis.

The results of experiments do show, and it is also verified in the investigation on superheated ammonia by the writers, that the frictional resistance varies approximately with the density of the fluid, the square of the velocity, and the pipe diameter. Since the coefficient of friction is not a constant for all conditions of flow, it may be inferred that the resistance varies as some power other than unity with the density, and as some power other than two with the velocity. Pipe diameter and roughness also play an important part in producing pressure drop. In general, the roughness effect diminishes with an increase in pipe diameter.

A definite relation occurs between the friction factor and the ratio known as Reynolds' number. This ratio

Ammonia Pipe Sizes

By R. C. Doremus

is composed of the dimensions of the pipe, the average velocity of the fluid, the density and the absolute viscosity of the fluid.

The friction factor and Reynolds' number are a function of variables combined in such a way to give a dimensionless result for each. It is upon this basis that the results of our ammonia investigation were analyzed. It was proven that the laws of similarity hold equally well for ammonia as for steam, air, oil, brine and water.

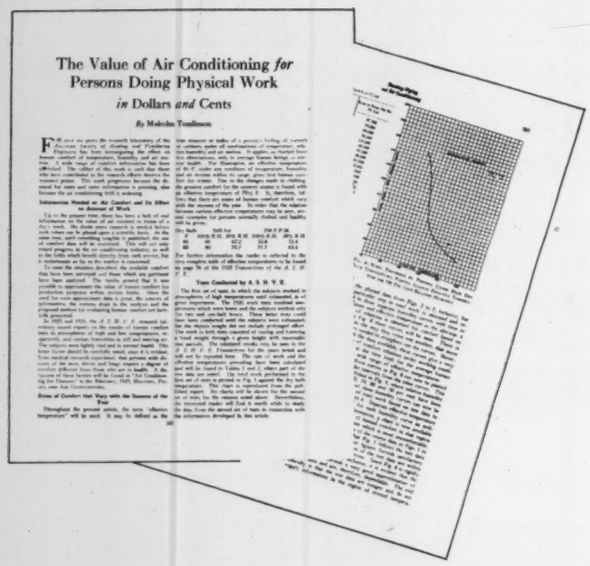
Sometime in the future, the Engineering Experiment Station at the University of Illinois will publish a bulletin concerning the flow of a fluid in pipes. In the investigation using this fluid the pipe diameter was changed and it was found that the laws of similarity hold regardless of the pipe diameter.

So it is to be concluded that it is only necessary to have complete data for one size pipe alone. In the above-mentioned article by the writers, a problem was solved finding the pressure drop in a 1½ in. pipe, whereas the data were obtained on a 1 in. pipe. A larger size pipe could be treated in the same manner. It is better to base calculations upon data obtained from the smaller size pipe because the friction factor tends to decrease slightly as the roughness effect diminishes, or as the diameter increases. Surely this method gives the greatest factor of safety.—*John C. Reed, Edgar E. Ambrosius.*

Effects of Air Conditioning

"The Value of Air Conditioning," *by Malcolm Tomlinson.* Page 381, May, 1930

I HAVE read Mr. Malcolm Tomlinson's excellent article, "The Value of Air Conditioning for Persons Doing Physical Work," in your May, 1930, issue, with great interest. He has collected some valuable data and is pointing the way in which plant execu-



The Value of Air Conditioning *for* Persons Doing Physical Work *in* Dollars *and* Cents

By Malcolm Tomlinson

tives must approach the question of ventilation in the future. The effect on health of reactions to conditions of temperature and humidity cannot be neglected. If the individual will be thoroughly examined when he makes the complaint of improper air conditions, which to others are acceptable, evidence will invariably be found pointing to lowered resistance. Abscessed teeth, tonsils or other masked foci of toxic poisoning seem to make the individual more susceptible to the effects of air changes.

Before fixing any standard of ventilation, a fuller investigation must be made. The effects of temperature and humidity are altered by the velocity of the air flow, and the inter-relationship of these three is so close that the discussion and investigation of any one factor must presuppose the fixation of the other two. The even distribution of incoming air to form as even a flow as possible is the desideratum for which we must work.

The so-called comfort zones in ventilation are dependent also on the air conditions existing out-of-doors, and when charted show a definite inter-relationship. Standards established as satisfactory for winter conditions would be unsatisfactory in summer. The designers and builders of any system must make allowance for suitable adjustment.

Workers Become Acclimated

Those industries which need fixed temperature and humidity by nature of the material used and the effects of moisture on its expansion have a condition to which the workers become accustomed or acclimated, but the question of the maximum personal efficiency in these occupations is sacrificed to the need of the occupation. The coal passer who is accustomed to working in temperatures as high as 120 to 135 F does his work by reason of individual adaptation to the occupation. No possible excuse exists for this temperature, but we try to correct it, with small success. These are extremes of the question. Mr. Tomlinson's article has laid a good foundation for further investigations and we hope he can continue them with equal success.—*George W. Calver*, Commander (M. C.) U. S. N.; Physician to House of Representatives, Washington, D. C.

Natural Gas Used for Heating in California Town

"Electric Air Heating," *by H. L. Stiles.* Page 106, February, 1930, issue

H. L. STILES, author of a very interesting article on "Electric Air Heating," in your February issue mentions San Luis Obispo, California, as an example of "an all-electric town where practically all domestic, public and industrial heating and cooking is done electrically."

It is evident that Mr. Stiles has been misinformed. In justice to the gas industry and in the light of the following data furnished by Mr. R. E. Easton, of the Santa Maria Gas Company which supplies natural gas to San Luis Obispo, I feel certain that you will want to correct any misunderstanding concerning this modern California town which may have been created by Mr. Stiles' article:

Population of San Luis Obispo.....	12,000
Number of gas meters.....	3,853
Total gas "send-out," January, 1930,	27,721,100 cu. ft.

It will be seen by Mr. Easton's figures that the average consumption per meter of natural gas in San Louis Obispo in January was in excess of 6,000 c. f. and apparently bears out Mr. Easton's belief that his company has 98 per cent of the heating and cooking business in that community.

Gas Unavailable in Buellton

Mr. Stiles also mentions Buellton as another example of the "all-electric" town. In this statement he may be somewhat nearer correct since natural gas is not yet available to that community. Buellton is a very small community at a cross roads and—including a twenty-five room hotel, restaurants, auto court and garages—may have approximately twenty all-electric consumers. Owing to the small size of the community and the fact that the nearest gas mains are sixteen miles distant, it has been found inadvisable so far to build transmission mains of that distance to supply such a small number of potential consumers.—*W. D. Thurber*, Chairman, Pacific Coast Gas Association, Committee on Advertising & Publicity.

Mr. Stiles Replies

This is in regard to the statement made in my article "Electric Air Heating" relative to the electrification of San Luis Obispo and Buellton.

Advice that I had received from the Pacific Coast informs me that these two towns, though to a great extent electrical, have gone over very strongly to natural gas due to the fact that the fields are located but about thirty miles away in Santa Maria.

It is possible that the article in which I gained the impression that these towns were all-electrical was written sometime before the natural gas lines were installed.

I will appreciate your advising Mr. Thurber that his criticism is, in my opinion, justified.—*H. L. Stiles.*

Heating·Piping
and Air Conditioning

American Society of Heating and Ventilating Engineers JOURNAL SECTION

1895

JULY 1930

Material in the Section prepared by Publication Committee: G. L. Larson, *Chairman*; H. H. Angus, and W. A. Rowe ; A. V. Hutchinson, Manager of Publications

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Application of Air Conditioning to Premature Nurseries in Hospitals

By C. P. Yaglou[a] (*MEMBER*), Philip Drinker[b] (*MEMBER*) and K. D. Blackfan[c] (*NON-MEMBER*), Boston, Mass.

DURING the past four years, the authors have had an opportunity to study at the Infants' Hospital (Boston) the growth and development of premature infants under accurately controlled air conditions. The results indicate that mechanical air conditioning can be applied with particular success in the institutional care of premature infants.

The purpose of this paper is to discuss from the engineer's point of view the air conditioning requirements for such nurseries, as these conditions have been determined in this study, and to suggest the types of mechanical equipment suitable for such installations. The medical aspects of the work will be discussed in detail elsewhere.

Nature of the Problem

A premature infant is taken to mean any infant born between the sixth and ninth month of foetal age. These infants are small, weighing between 1½ and 5½ lb., and the majority of them require special treatment if they are to survive. In the same category, so far as hospital care is concerned, are the congenitally diseased and other debilitated infants.[d]

The condition of first importance in the care of such infants is the conservation of body heat and energy, for their vital organs are not completely developed. The metabolism, or internal heat production, is low compared with that of full term, normal infants; moreover, the heat loss is greater than that of normal infants on account of wrinkled skin surfaces and absence of fat deposits in the skin. These facts explain the gradual decline in body temperature after birth, a condition which often persists unless external heat is applied. Inadequate functioning of the heat regulating mechanism in prematures may result in low or in high body temperatures, or, again, in wide fluctuations between the two, depending on the environmental temperature conditions. Wide fluctuations in temperature sometimes prove fatal, since they call on more reserve energy than the premature infants possess. In short, premature infants generally exhibit marked inability to maintain a normal body temperature by their own efforts and they show little resistance to infections, especially respiratory infections. The mortality rate exceeds 50 per cent and has two peaks, one occurring in cold weather and the other in excessively warm and humid weather.

Success in the treatment of premature infants depends mainly on four factors: (*a*) stabilization of body temperature, (*b*) proper nutrition, (*c*) nursing care, and (*d*) prophylaxis against infection. The importance to these infants of adequate ventilation—sufficient air changes without drafts and the maintenance of optimum temperature and humidity conditions—is demonstrable.

Present Methods of Controlling Body Temperature in Prematures

The usual methods employed for controlling the body temperature of premature infants are the use of heated beds, electric pads, and electric incubators and the application of plenum systems of heating and ventilation. Hess[1] gives an excellent review of the history and development of these methods. The failure to offer a satisfactory solution of the problem of heat regulation in prematures would appear, in the light of the present study, to be largely explained by an insufficient knowledge of the air conditioning requirements and by inability to control the air conditions to the desired degree. In other words, although the importance of air temperature has been generally appreciated, the direct effects of humidity and rate of air change upon body temperature, with their indirect effects on nutrition, growth, infection, and the like, have not been fully understood. Most of the methods now in use have failed to fulfill the environmental needs of premature infants on account of limited air space, inadequate ventilation, insufficient humidification in winter, and lack of facilities for cooling and dehumidifying the air in warm weather. Where mechanical ventilation is used, there is a tendency to fix the temperature of a single room at 80 F, regardless of humidity and of the individual requirements of the infants. These mechanical systems, too, are rarely equipped to provide cooling and dehumidification of the air in warm weather. The necessity for such provision is clearly illustrated by the work of Dodd and Wilkinson[2], who discuss the relation between excessive summer heat and obscure fevers in infants.

Air Conditioning Requirements in Premature Nurseries

From the foregoing discussion, it will be evident to the ventilating engineer that the general requirements for premature nurseries can be met most satisfactorily by the use of a central system of air conditioning which includes cooling as an essential part of the general equipment, even though the latter may be needed for only a month or two each year. Refrigeration is usually available in hospitals at small expense, since most modern establishments are equipped with brine circulating systems.

[a] Assistant Professor of Industrial Hygiene, Harvard School of Public Health.
[b] Assistant Professor of Industrial Hygiene, Harvard School of Public Health.
[c] Professor of Pediatrics, Harvard Medical School.
[d] Congenitally diseased or sick premature infants are those who suffer from congenital anomalies, birth injuries, and acute or chronic infections.
Presented at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Minneapolis, Minn., June, 1930.

[1, 2] See Bibliography.

Humidification of the air in premature nurseries by means of steam humidifiers, hot water pans, or mechanical atomizing devices inside the rooms and dehumidification in warm weather by means of calcium chloride have proved quite ineffectual.

In the air conditioned nurseries of the Infants' Hospital, a ventilation rate of 25 air changes per hour was required to keep the room atmosphere free of odors[e] and to maintain the desired temperature and humidity conditions. An air movement of about 15 ft. a minute over the beds, as measured by the kata-thermometer, proved satisfactory.

It is perhaps unnecessary to point out that neither the comfort zone nor the effective temperature index determined for adults at the Research Laboratory of the Society[3 4] hold for these infants, who differ so much from normal adults in their metabolic and circulatory functions and in the development of their sweat glands.

The preliminary survey showed that the temperature requirements of premature infants vary widely according to their general condition and their body weight. The amount of clothing worn and the humidity of the air are also of importance. Accordingly the infants were classified into two main groups: (*a*) the normal premature and (*b*) the congenitally diseased infants. Each main group was divided into sub-groups according to body weight, as shown in Table 1. The clothing worn consisted in general of a shirt, a diaper, and a flannel jacket; the bedding of two light woolen blankets and a spread. The temperature and humidity requirements for the various groups were determined experimentally over a period of four years (1926 to 1929) by so adjusting the temperature conditions in two adjoining rooms and in electric incubators that fluctuations in body temperature were minimized.

From observations on body temperature, gain in weight, incidence of diarrhea, mortality, and general behavior of the infants under various humidity conditions, a relative humidity of 65 per cent was adopted. When humidities as low as 30 per cent (a considerably higher value than that prevailing in unconditioned nurseries during cold weather) were maintained for two weeks or longer, the body temperature became unstable, gains in weight diminished, the incidence of diarrhea increased, and mortality rose. Continuous exposure to air conditions with 55 to 65 per cent relative humidity, on the other hand, gave very satisfactory results over a two-year period (1928 and 1929). It is of interest to notice that the relative humidity of 65 per cent which was adopted as the optimum for prematures is in close agreement with the humidity conditions recommended by Huntington[5] for adults of the white race.

The temperature requirements for normal prematures (Table 1) varied from a minimum of 75 F to a maximum of 88 F. As will be seen from the same table, the temperatures required by the congenitally diseased group are too various to make group treatment practicable; these infants were therefore cared for individually in electric incubators placed inside the larger nursery, where the surrounding air was kept at a relative humidity of 65 per cent. The temperature requirements of the normal prematures varied over a range of 13 F,

[e] These odors emanate chiefly from loose and frequent stools and vomitus common among prematures.

[3, 4, 5] See Bibliography.

TABLE 1—AIR CONDITIONING REQUIREMENTS OF PREMATURE INFANTS AT INFANTS' HOSPITAL (BOSTON), 1926-1929.

WEIGHT GROUPS LB.	NORMAL PREMATURE INFANTS			CONGENITALLY DISEASED INFANTS		
	ROOM TEMPERATURES, F. (DEW-POINT, 64 F; AIR MOVEMENT, 15 FT. A MINUTE)			INCUBATOR TEMPERATURES, F. (RELATIVE HUMIDITY OF ROOM, 65%; AIR MOVEMENT, 15 FT A MINUTE)		
	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM	AVERAGE
1.5–1.9	83	88	86.0	86	100	93.5
2.0–2.4	82	87	84.5	86	98	90.5
2.5–2.9	78	86	83.0	84	95	88.0
3.0–3.4	77	86	80.5	79	90	83.5
3.5–3.9	75	85	78.5	79	88	81.0
4.0–4.4	75	85	77.0	78	86	79.0
4.5–4.9	75	85	76.0	76	85	77.0
5.0 and over	.....	80	.....	.....	85	.....

as compared with a range of 24 F for the congenitally diseased infants.

A more thorough discussion of the methods employed in determining the air conditioning requirements and of the physiologic data secured under various air conditions will be published elsewhere.

Table 2 shows how a single central apparatus, furnishing conditioned air at 64 F dew-point to two nurseries, was made to meet the requirements of all the infants. Normal prematures weighing 1.5 to 3.5 lb. were cared for in the smaller nursery in an atmosphere of 80 to 85 F and a relative humidity of 50 to 59 per cent. The larger group of normal prematures—those weighing from 3 to 4.5 lb. occupied the larger nursery where the temperature was 77 F and the relative humidity 65 per cent. The special requirements of certain infants within each group were met by the use of hot water bottles and by varying the amount of clothing worn. As soon as the infants reached a weight of 5 lb., they were removed to the wards.

On account of the limitations of the air conditioning equipment, the relative humidity in the smaller nursery has necessarily been somewhat below 65 per cent, depending on the temperature of the room. Arrangements are now being made, however, to install auxiliary apparatus which will raise the relative humidity in this nursery also to the 65 per cent desired.

Since the number of congenitally diseased infants to be treated at any one time is small, they can be cared for in individual electric incubators, placed inside the larger nursery with tops open, and the heat adjusted according to requirements. Temperatures as high as 100 F are sometimes temporarily employed. In this way, the infants breathe the comparatively cool room air at about 65 per cent relative humidity and the attending doctors and nurses are not subjected to extreme temperature conditions.

Since June, 1927, the procedure outlined in Table 2 and described in this paper has been followed with very satisfactory results. Stabilization in body temperature was associated with reduction in the incidence of diarrhea and in the general mortality. Infections were reduced to a minimum and gains in body weight increased. These striking benefits are to be attributed not only to improved air conditions but also to advances in medical treatment and to improvement in nursing and general care. It is fair to conclude, however, that the introduction of me-

chanical air conditioning has proved a distinct advance in the care and treatment of premature infants.

The Air Conditioned Nurseries at the Infants' Hospital (Boston)

General Specifications and Recommendations for Future Installations: The nurseries consist of two adjoining rooms 12 ft. x 8 ft. x 12 ft. and 12 ft. x 12 ft. x 12 ft., the last dimension being the height. Both rooms are equipped with double windows. At the time the air conditioning system was installed, the larger room was partitioned into cubicles and the partitions were allowed to stand, since they did not interfere with ventilation.

The system was originally designed for 45 air changes per hour in each room, with provision for reducing the air changes to 20 per hour by means of variable speed fan-motors. Later it was found that the actual requirements were only 25 changes per hour, so that it was possible to add a third room to the system, thus making use of the full capacity of the air conditioning apparatus. This new room, measuring 11 ft. x 20 ft. x 9 ft. is used as a special observation nursery for full term infants suffering from such ailments as fever, diarrhea, and other gastro-intestinal disturbances.

The apparatus has sufficient capacity to maintain the three rooms at a maximum temperature of 110 F with a maximum dew point of 80 F, when all the air is taken from out of doors at 0 F. In summer, the rooms can be cooled to 75 F and the dew-point lowered to 60 F when the outdoor dry-bulb does not exceed 95 F and the wet-bulb 75 F.

By referring to Table 2, it can be seen that the maximum winter conditions for which the apparatus has been designed are needlessly high, and that it would be adequate to design such systems in the future for temperatures of 90 F and 80 F in the smaller and larger rooms respectively, and for a dew point of 70 F. The refrigeration capacity of the equipment happens to be quite close to the actual requirements, as shown in Table 2. No recirculation allowance should be made in the design of such systems.

Description of Apparatus: The installation at the Infants' Hospital consists of an individual supply system for furnishing conditioned air to the three nurseries and of an individual exhaust system for withdrawing air from the rooms. The conditioning apparatus is located in the basement.

The supply system consists of the following:

(*a*) Outdoor air intake, containing a weather-proof hood and a screen

(*b*) Light weight copper tempering coils, controlled thermostatically

(*c*) A dehumidifier of the horizontal mist spray type for humidifying the air in winter and for cooling and dehumidifying the air in summer. Humidification in winter is accomplished by means of a closed type water heater which warms the spray water. In summer the spray water is cooled in a Baudelot cooler, on top of which the dehumidifier is mounted. A centrifugal pump circulates the spray water

(*d*) A supply fan, which draws the air through the dehumidifier and forces it through the rooms

(*e*) Individual light weight copper reheaters, controlled thermostatically, for warming the air to the temperature desired at the room inlet registers

(*f*) Individual supply ducts, fitted with dampers and registers, near the ceiling of the rooms for even distribution of the air inside the rooms.

The exhaust system consists of the following:

(*a*) Individual exhaust ducts, fitted with dampers and registers, near the floor of the rooms for withdrawing the used air from the rooms

(*b*) Exhaust fan to which the individual exhaust ducts from the rooms are piped

(*c*) Recirculating ducts for recirculating part of the air at the inlet side of the dehumidifier

(*d*) Main exhaust outlet duct which discharges the used air out of doors.

The Central Apparatus: The dehumidifier is of standard construction. It is made of galvanized iron and has the following dimensions: width and height, 2 ft. 0 in.; length, 9 ft. 0 in.; over-all height, including tanks, 3 ft. 0 in. A spray system of 27 sprays is arranged in three banks, two of which spray in the direction of the air flow and the third against it.

The water circulating system consists of a centrifugal pump having a rated capacity of 40 gal. per minute at 30-lb. pressure at the pump discharge.

The water heater is of the closed type. It is capable

TABLE 2—AIR CONDITIONING SCHEDULE ADOPTED FOR PREMATURE NURSERIES OF INFANTS' HOSPITAL (BOSTON)

CLASSIFICATION OF INFANTS	WEIGHT GROUPS LB.	TEMPERATURE F	RELATIVE HUMIDITY PER CENT	AIR MOVEMENT FT. PER MIN.	METHOD OF TREATMENT
Congenitally diseased and malformed infants.....	1.5–5.0	(86–100)*	†	15	Infants placed in open top incubators inside large nursery and heat gradually adjusted according to requirements.
Normal prematures.....	1.5–3.4	80–85	59–50	15	Infants placed in small room and room temperature adjusted according to requirements. Hot water bottles (110 F) used in special cases.
	3.5–4.9	77	65	15	Infants placed in large nursery. Hot water bottles (100 F) used sparingly in special cases.
	5.0 and over	70–74	Ward	Ward	With exception of definite cases of hypothermia, infants are removed to wards.

* Incubator temperatures taken between basket and metal wall.
† Infants breathe cool room air at about 65 per cent relative humidity.

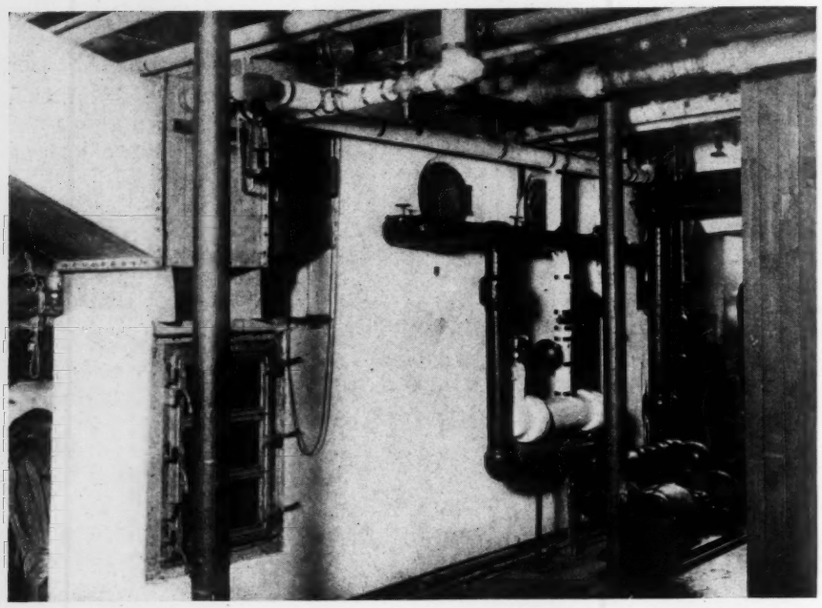

FIG. 1—CENTRAL AIR CONDITIONING APPARATUS

of warming 40 gal. of water per minute through a maximum of 10 F with steam at 5 lb. pressure. Originally the water heater was equipped with a water by-pass and a three-way diaphragm valve for the control of humidity by the wet-bulb temperature method, but this arrangement proved to be unsatisfactory for our purpose and is no longer used.

The Baudelot cooler is 2 ft. wide by 4 ft. high by 15 ft. long. The cooling coils are made up of 2 in. wrought iron pipes, black on the inside and galvanized on the outside. They are arranged in two vertical rows, each 8 pipes high and about 10 ft. long. The flooding troughs, made of galvanized iron, are of the saw-tooth adjustable type and extend over the entire length of the coils. The refrigerant is brine at about 12 F, which is taken from the main brine circulating system of the hospital. Under our operating conditions, the refrigeration capacity is about 7 tons.

The fans are of the multivane type, direct connected to variable speed d-c. motors, by means of which their speed may be varied between 600 and 300 rpm. The capacity of the supply fan at 600 rpm is about 2,000 cfm when it operates against a static head of about 0.7 in. of water. The capacity of the exhaust fan at the same speed is about 1,500 cfm at 0.15 in. static pressure. According to the authors' experience, both supply and exhaust fans should have the same capacity and should not be direct connected on extended motor shafts.

Fig. 1 shows a general view of the central air conditioning apparatus.

System of Duct Work: The supply ducts extend across the entire length of the rooms on an interior wall, at a height of 8.5 ft. from the floor. Air distribution is secured by means of adjustable louvre registers, spaced along the face of the ducts about 2 ft. on centers. The conditioned air is blown across the rooms directly against the exposed walls and glass, which constitute the cooling surfaces in winter and the warming surfaces in summer.

After circulating across the rooms, the air is withdrawn near the floor by means of exhaust ducts, which are similar in all respects to the supply ducts. Figs. 2 and 3 show the general arrangement of the supply and exhaust duct system in the two premature nurseries. They also show the cubicles, beds, supply closet, etc.

Some difficulty was experienced in distributing the air uniformly inside the rooms so as to secure an air movement of about 15 ft. a minute, as measured by the katathermometer, in the zone occupied by the infants. This was finally accomplished by reducing the air changes from 45 to 25 an hour and by adjusting the louvres of the registers so as to deflect the air toward the ceiling and thence against the windows.

The reduction in the number of air changes from 45 to 25 an hour has, in addition, considerably diminished the air noise in the ducts. According to the authors' experience, both supply and exhaust risers for such systems should be designed for air velocities of 450 ft. per minute or less, according to the size of the ducts.

Temperature Control: The problem of temperature control has been a most difficult one, because premature infants seem to be more sensitive to temperature changes than are the majority of the regulators which were tested. The small size of the rooms adds to the difficulty.

In addition to the size of the room and the type of regulator used, accuracy in temperature control was found to depend upon location of thermostats, velocity of air over the thermostats, rate of air change in rooms, type and amount of heating surface controlled, type and size of controlled valve, and weather conditions. Some of the results secured with different regulators have been published elsewhere.[6] According to these data, sling psychrometer readings showed that the temperature fluctuations in the rooms ranged from a minimum of 2.9 F to a maximum of 8.9 F, depending upon the type and location of the thermostat.

The best regulation was secured by means of a gas filled capillary coil bulb, made of fine copper tubing 60 ft. long, which limited the fluctuation to 2.9 F. After about a year's operation, however, corrosion inside the copper

[6] See Bibliography.

tubing stopped up the capillaries of the instruments and it was necessary to replace them with ¼-in. copper bulbs about 30 in. long. These bulbs are not as sensitive as those of the capillary type, but they are much more dependable. They are exposed inside the exhaust ducts in the region of maximum velocity, where they work best. The operating mechanisms of the thermostats are mounted on the wall just outside the nurseries and connect with the bulbs by means of armored flexible tubing. These thermostats control the steam diaphragm valves on the reheaters, by the medium of compressed air. With this arrangement, it is possible to control the room temperature within a range of 3.5 F, as recorded by the sling psychrometer.

In a more recent installation of this type, the temperature fluctuation was reduced to about 2.5 F by the judicious choice of regulators and diaphragm valves.

Humidity Control: The control of humidity by the wet-bulb temperature method was unsatisfactory for this particular installation, because the wet-bulb temperature in the rooms varied as much as 6 F and the system was loaded with many automatic devices, which required constant attention.

By rearranging the regulators and valves and by eliminating superfluous pieces of apparatus, the authors were able to use a central dew-point control, which proved much superior to the former system. In this modified system, the dew-point regulator is placed in the path of the air leaving the dehumidifier. In winter the regulator controls the supply of steam to the water heater by means of compressed air and thus warms the spray water as desired. In summer the regulator controls a three-way valve on the suction side of the water pump. One side of this valve connects to the pump itself, another side to the refrigerated water in the Baudelot cooler tank, and the third side to the warm water in the dehumidifier tank. The desired dew-point is maintained automatically by mixing the right proportion of cold water from the cooler tank with warm water from the dehumidifier tank. When the dew-point of the air leaving the air washer drops slightly, the regulator partially closes the cold water port of the three-way valve and opens the warm water port sufficiently to raise the temperature of the spray water to the required degree. If the water in the dehumidifier tank is not warm enough to secure the dew-point for which the regulator is set (under this condition, the warm water port is wide open and the cold water fully closed) the steam diaphragm valve on the water heater is automatically opened to raise the temperature of the spray water. The tension of the springs in the three-way valve and the heater valve is adjusted in such a way that little attention to hand valves is required.

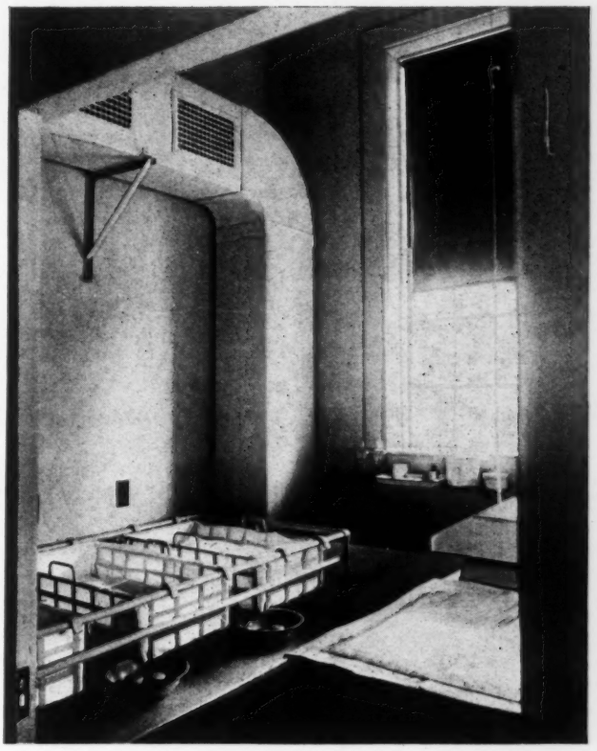

FIG. 3—SUPPLY DUCT IN SMALLER PREMATURE NURSERY

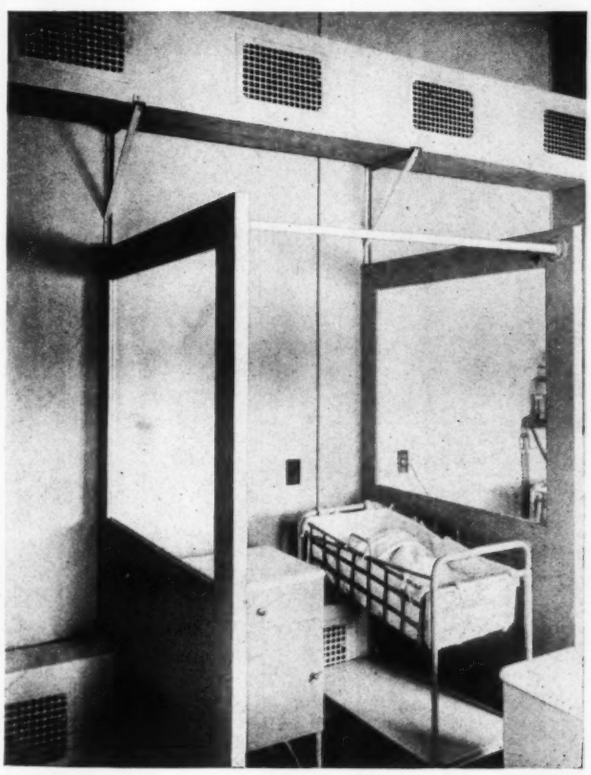

FIG. 2—SUPPLY AND EXHAUST DUCTS IN LARGER PREMATURE NURSERY

The water in the cooler tank is automatically maintained at about 59 F by means of a water thermostat controlling the brine valve to the cooling coils.

Dry- and Wet-Bulb Temperature Recorders: Continuous and permanent records of the dry- and wet-bulb temperatures of the air in the rooms are secured by means of automatic recorders of the remote type, which are mounted on the wall just outside the nurseries. The thermostatic bulbs of these instruments are exposed inside the exhaust ducts in the current of air leaving the rooms, where their sensitivity is increased considerably by the air movement. It was found that the condition of the air in this region represented quite closely the average condition of the air in the rooms.

Operation of Apparatus

In winter the incoming air is warmed automatically by the preheater to about 65 F. In passing through the spray chamber, the air absorbs a sufficient amount of moisture to saturate it at a temperature somewhat higher than the dew-point of 64 F at which the rooms are kept. The difference between the dew-point at the apparatus and that in the rooms represents the loss of moisture by absorption and diffusion through the walls of the rooms. In order to compensate for this loss, the dew-point of the air leaving the dehumidifier is increased systematically 1 F each month beginning in October, until it reaches a maximum value of 68 F in January, the coldest month in Boston. Beginning in February, the dew-point is gradually reduced 1 F each month until May, when it is brought back to 64 F. From May to October, the dew-point in the rooms is practically the same as that at the apparatus, except during short periods of extreme weather.

During the heating season, the reheaters warm the air to whatever temperature is demanded by the room thermostats. Since no direct radiation is used in the rooms, the ventilating current must furnish sufficient heat to balance all the heat losses and to maintain the rooms at the desired temperature. This is accomplished with a maximum drop of about 10 F in the temperature of the ventilating current.

In summer the warm and humid air from out of doors is cooled and dehumidified to 64 F by contact with the cold water spray. In passing through the fan and duct work, the air increases in temperature from 2 to 7 F, depending upon the location of the room and upon the weather conditions. In circulating through the rooms, the air absorbs sufficient heat from the warm walls, glass, lights, and bodies of occupants to raise its temperature and at the same time to decrease the relative humidity to the desired degree. If the heat leakage into the rooms through the walls and glass is not sufficient to produce this effect, as is often the case in cool weather, the reheaters automatically furnish whatever additional heat is needed. Recirculation is used sparingly on account of the possibility of infection.

Success in applying these systems depends as much upon operation as upon design. The operation of the equipment, therefore, should not be entrusted solely to the hospital engineer. The system should be thoroughly checked by an expert twice every year and care should be taken to keep the apparatus clean, for if mud and fungus are allowed to accumulate in the air washer and Baudelot cooler tanks, musty and sour odors will pollute the air in the rooms.

Cost Data

The initial cost of the installation for the two premature nurseries alone was about $5,700.00. The addition of the third nursery brought the total cost to about $7,000.00. This sum represents the minimum cost of an installation of this type.

The itemized yearly cost for operating the system continuously at full capacity is as follows:

Electric power ($15.00 per year per kw. of demand and $0.015 per kw-hr. of consumption)	$ 370.00
Steam ($0.10 per million Btu of demand and $0.60 per million Btu of heat)	670.00
Refrigeration ($1.25 per ton)	300.00
Water and compressed air	60.00
Supervision	300.00
Repairs and maintenance	150.00
Yearly operating cost (exclusive of depreciation and interest on capital investment)	$1,850.00

The unit costs shown are those charged to the Infants' Hospital by the Harvard Medical School Power Plant.

The operating cost is actually somewhat less than $1,600.00 because the special nursery for full term infants is not used continuously. The yearly operating cost for the two premature nurseries alone is about $1,200.00.

Summary

A four year study of the influence of air conditions on the growth and development of premature infants at the Infants' Hospital (Boston) showed that a mechanical air conditioning system of the central station type could be applied with marked success to the group care of these infants. The air conditioning requirements for the premature nurseries at the Infants' Hospital were found to be a ventilation rate of 25 air changes per hour, an air movement of 15 ft. a minute over the beds, a relative humidity of 65 per cent, and environmental temperatures varying approximately from 100 to 76 F, depending on the general condition of the infant and its body weight. In order to meet these requirements, two conditioned nurseries were necessary, one about twice as large as the other. The special needs of congenitally diseased infants, particularly those of the 1.5 to 2.0 lb. groups, were taken care of most satisfactorily by the use of open top electric incubators or heated beds placed inside the larger nursery.

The system should be designed for maximum indoor temperatures of 80 and 90 F in the larger and smaller nurseries respectively and for a dew-point of 70 F in winter and 60 F in summer. No recirculation allowance should be made in estimating the capacity of such systems. The problem of temperature control deserves especial attention, because premature infants are peculiarly sensitive to temperature changes.

The application of air conditioning to the premature nurseries of the Infants' Hospital was followed by a marked reduction in the incidence of diarrhea and in the mortality rate. Infections were reduced to a minimum and gains in body weight increased. These benefits are attributed to advances in medical treatment and improvement in nursing and general care, as well as to the installation of the air conditioning system described.

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Loss of Head in Submerged Orifices

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Introduction

IN DESIGNING pipe lines for water heating systems it is frequently necessary to increase the friction in a portion of the system in order to secure a balanced flow of water to the several radiators in the system. The additional friction head may be secured by inserting valves constructed so that the opening through the valve is adjustable and can be reduced sufficiently to secure the desired loss of head. The additional friction head may also be secured by inserting sections of pipes of sufficiently small size.

When neither of these two methods is to be used the additional friction head may be produced by contracting the cross section of the pipe in one or more places by inserting a union with a metal plate having an opening sufficiently small to secure the required loss of head.

Fig. 1 shows such a union with a plate having a central circular orifice. The stream of water flowing through the orifice will have a contracted section, as indicated in the figure. The head necessary to produce the increased velocity at the smallest section of the contracted

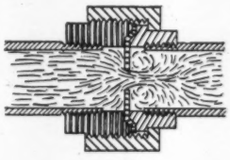

FIG. 1—UNION IN 1-IN. PIPE WITH DIAPHRAGM HAVING CENTRAL CIRCULAR ORIFICE AND SHOWING PROBABLE FLOW OF WATER THROUGH ORIFICE

stream will be (approximately) the loss of head caused by the orifice, because the energy stored in this increased velocity will be very largely transformed into heat.

If the degree of contraction of the stream after it has passed the orifice were known, it would be possible to calculate (with a fair degree of accuracy) the loss of head caused by the orifice. For example, if for the case shown in Fig. 1, the diameter of the pipe is 1.042 in., the diameter of the orifice 0.5 in., and the diameter of the contracted stream at the smallest cross section 0.4 in., as seems to be the case when the stream of water is discharging into air, then, for a velocity of 2 in. per second in the pipe, the velocity at the smallest cross section of the stream would be 13.6 in. per second, since the velocities are inversely proportional to the squares of the diameters. The head necessary to produce the increased energy stored in this increased velocity is

$$\frac{1.13^2 - 0.167^2}{64.4}$$ or 0.019 ft. or 228 milinches.

It is not known, however, that the smallest cross section of the stream will be 0.4 in., nor is it known that the entire energy stored in the increase in velocity will be transformed into heat; a portion may be consumed in producing an increased pressure head in the section of the pipe beyond the orifice. In addition, a portion of the loss of head may be caused by friction along the perimeter of the orifice.

On account of these uncertainties it is necessary to make experimental determinations of the losses of head caused by orifices in order to have reliable data for use in the design of pipe systems. For example, in the case cited, experimental determinations (see Fig. 6) show that the loss of head is 150 milinches instead of 228, as indicated by the calculation.

Description of Apparatus and Tests

In order to make such a determination for diaphragm orifices in a 1-in. pipe, the apparatus shown in Figs. 2 and 3 was constructed at the Texas Engineering Experiment Station, in cooperation with the A. S. H. V. E. The pipe used was a good section of a new standard black pipe calibrated and found to be 1.042 in. in diameter. The two unions were standard black unions; the three piezometer rings, one of which is shown in Fig. 4, were of brass soldered to the pipe which was perforated with eight holes 0.067 in. in diameter and spaced 45 deg. apart; the middle ring was used to remove air that might be trapped in the pipe between the two unions; the two outer rings were connected to the manometer tube and served to measure the loss of head in the pipe between the two outer rings. The connection of the piezometer rings to the manometer was made as shown in order to trap any air that might escape through the piezometer rings and prevent its entering the manometer tubing where it would affect the manometer reading.

The test was conducted in the usual manner. That is, water was maintained at a constant head in the supply tank and allowed to flow through the pipe system into the weighing tank. When the flow had attained a steady state, readings were taken from which the velocity of the water in the 1 in. pipe could be calculated and the fric-

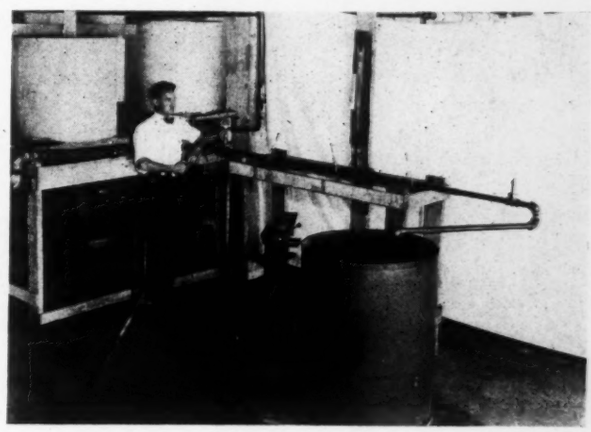

FIG. 2—APPARATUS FOR DETERMINING LOSS OF HEAD IN DIAPHRAGM ORIFICES

[1] Director, Texas A. & M. College, Engineering Experiment Station. Presented at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Minneapolis, Minn., June, 1930.

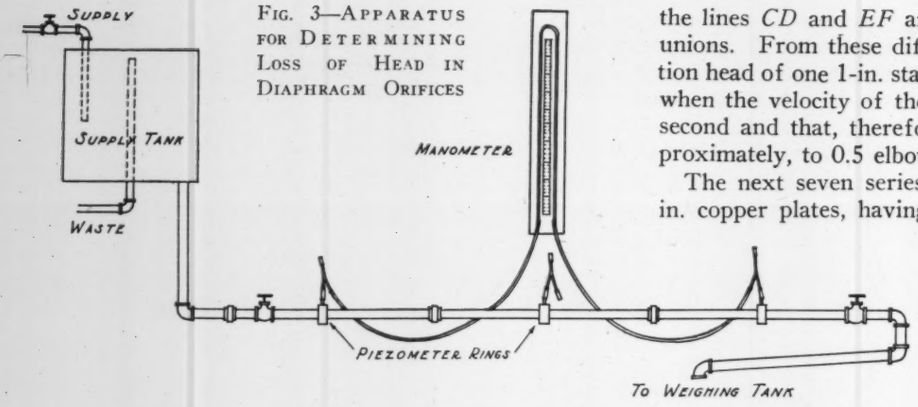

FIG. 3—APPARATUS FOR DETERMINING LOSS OF HEAD IN DIAPHRAGM ORIFICES

tion head between the two outer piezometer rings recorded.

Results of Tests

The first two series of tests determined the friction head in two standard black unions and in 4.25 ft. of standard black 1-in. pipe when the water was at a temperature of 63 F. The results of these tests are shown by line *AB*, Fig. 5. The experimental values shown by crosses were determined March 25, 1930, and those shown by triangles were determined March 26, 1930. On both days the water had a temperature of about 63 F and both sets of values lie quite accurately on the line *AB*.

After the tests with the orifices had been completed, the test with the unions only was repeated on April 4, 1930. At that time the water had a temperature of about 74 F and for this higher temperature a slightly lower friction head should exist because the viscosity of the water at 74 F is slightly lower than at 63 F. The values determined on that day are represented by the line *CD*. A separate study of these two lines (not reproduced in this paper) shows that the values derived from the line *CD* are about 7 per cent lower than those derived from the line *AB*. Theoretically, the difference should be only about 3 per cent, which is derived as follows: Reynold's numbers for a 1-in. pipe, and water at a velocity of 2 ft. per second and at temperatures of 63 F and 74 F are, respectively, 15,490 and 17,040. From a curve showing the relation between Reynold's number and the friction factor in the expression $\left[f \frac{l}{d} \frac{V^2}{2g} \right]$ for a 1-in. black iron pipe, it appears that the values of the two friction factors are, respectively, 0.032 and 0.031, and that, consequently, the friction head should be about 1/32 or about 3 per cent smaller for the 74 F water than for the 63 F water. Since there may have been a slight error in the recorded water temperatures (which were taken in the upper portion of the supply tank) it was concluded that the method of measuring losses of head in this investigation is sufficiently accurate for the purpose for which it was performed.

To determine the friction head of one union, the line *EF*, Fig. 5, was drawn to represent the friction of 70 F water in a standard 1-in. pipe according to the equation $h = 0.006371 V^{1.7767}$ taken from an earlier investigation by the author and published in *University of Texas* Bulletin No. 1759, page 31.

The differences between the friction heads shown by the lines *CD* and *EF* are the friction heads due to two unions. From these differences it appears that the friction head of one 1-in. standard black union is 60 milinches when the velocity of the water in the pipe is 10 in. per second and that, therefore, one union is equivalent, approximately, to 0.5 elbows, in the resulting loss of head.

The next seven series of tests were made with 0.027 in. copper plates, having central circular orifices of 0.3 in., 0.4 in., 0.5 in., 0.6 in., 0.7 in., 0.8 in., and 0.9 in. in diameter; one plate being placed in each of the two unions. The results of these tests were uniform except for the plates with 0.9 in. orifices. For this size orifice the friction head seemed to follow a law different from that according to which the friction heads in the other six plates varied. This difference may be caused by the fact that the 0.9 in. orifice differs so little in size from that of the pipe in which it was placed, and the results for this size orifice are not reported in this paper.

The results secured with the remaining six sets of plates are shown by the lines *GH, IJ, KL, MN, OP,* and *RS* of Fig. 5. It is interesting to note how accurately the observed values fall on the several lines shown on the figure.

When these six lines were first drawn their positions and directions differed slightly from those shown in Fig. 5. It is evident, however, that the loss of head through these several orifices must follow some definite law; that is, the six lines must all either be parallel to each other or there must be a gradual and regular change in their inclinations; similarly, the values of the losses of head for a velocity of 1 in. (or for any other definite velocity) must vary according to some definite law. So, after the six lines had been drawn, a study was made of the several slopes and also of the several friction heads for a velocity of 1 in. per second and it was found that, by making very slight changes in the locations and in the slopes of some of the six lines, they could be drawn so that they would follow a definite law and still represent, as accurately as they had done before, the experimental values secured in the tests. The study referred to is not reproduced in this paper and the six lines shown in Fig. 5 are those which were determined after that study had been made.

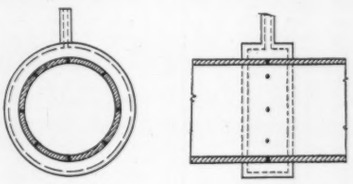

FIG. 4—PIEZOMETER RING AND EIGHT OPENINGS THROUGH PIPE TO DETERMINE PRESSURE HEADS

The line *VW* in Fig. 5 shows the tangents of the slopes of the several lines and the line *XY* shows the values of the loss of head for a velocity of 1 in. per second, both lines being plotted against the diameter of the respective orifices.

Having determined these six lines with sufficient accuracy, the value of the loss of head through one orifice, the 0.5 in., for example, can be easily found; it is half the difference between the values shown by the corresponding line *KL*, in this case, and the line *AB*. These

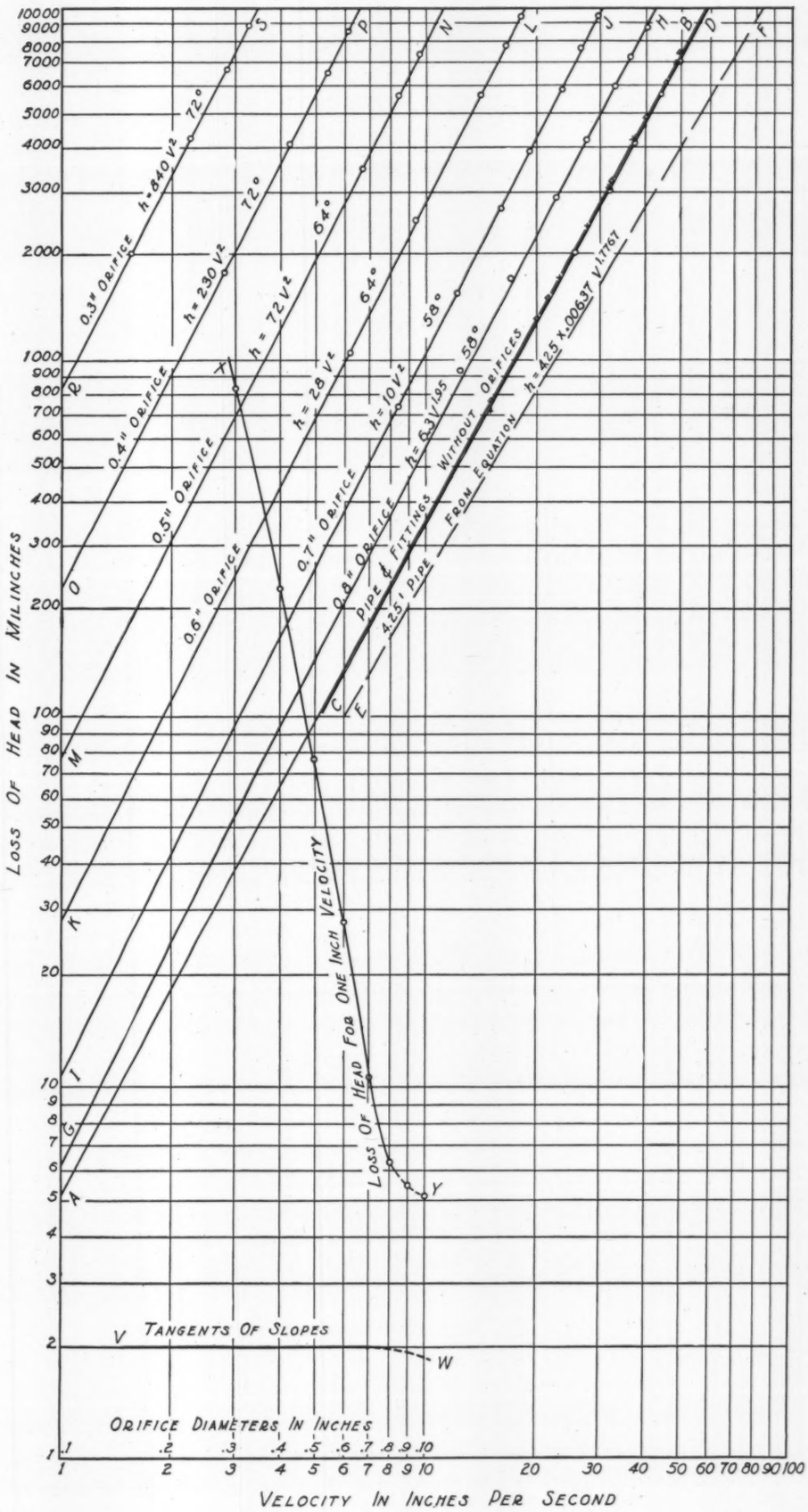
LOSS OF HEAD IN MILINCHES
VELOCITY IN INCHES PER SECOND
ORIFICE DIAMETERS IN INCHES
TANGENTS OF SLOPES
LOSS OF HEAD FOR ONE INCH VELOCITY
0.3" ORIFICE h=.840 V² 72°
0.4" ORIFICE h=230 V² 72°
0.5" ORIFICE h=72 V² 64°
0.6" ORIFICE h=28 V² 64°
0.7" ORIFICE h=10 V² 58°
0.8" ORIFICE h=6.3 V^1.95 58°
PIPE & FITTINGS WITHOUT ORIFICES
4.25 I PIPE FROM EQUATION h=4.25 x.0063 V^1.7757

Fig. 5—Losses of Head Determined by Means of the Apparatus Shown in Fig. 3 and Fig. 4

differences can be read directly from the diagram of Fig. 5, or they can be determined with greater accuracy by calculations from the equations of the two lines.

This was done for all six cases and the resulting losses of head are shown by the corresponding lines of Fig. 6 in which the losses of head are expressed in milinches and plotted against the velocity of the water in the 1-in. pipe, expressed in inches per second. It is evident from the diagrams of this figure that if the velocity of the water in the 1-in. pipe is 2 in. per second, the loss of head caused by a 0.5 in. orifice is 150 milinches.

To make the diagram of Fig. 6 more useful, the five dotted lines were added to represent the losses of head caused by the five corresponding orifices, namely: 0.35 in., 0.45 in., 0.55 in., 0.65 in., and 0.75 in. The locations of these lines were determined graphically as shown in Fig. 8 by plotting the velocity of the water against the corresponding orifice for several losses of head, namely: 10 in., 3 in., 0.7 in., and 0.2 in., and then finding, from the resulting curves, the velocities corresponding to the desired orifices for the same losses of head.

Practical Application of Results

To explain the use of the diagram, let Fig. 7 represent a set of risers supplying three radiators in a gravity circulation heating system. Let each radiator supply 10,000 Btu and let each radiator have 1-in. connections and no valves. Let the friction head through each radiator and through its connections to risers, *i. e.*, from *A* to *B*, or *C* to *D*, or *E* to *F*, be 460 milinches. Let the temperatures of the water be 180 F and 160 F; the pressure head tending to force water through Radiator II will then be 996 milinches higher than that tending to force water through Radiator I.

If the two risers connecting those two radiators are of

1¼-in. pipe, the friction head in the 24 ft. of 1¼-in. pipe will be 288 milinches; this is less than the available pressure head by 708 milinches, and it is necessary to provide 708 milinches of additional friction. From the pipe chart it will be found that if 10,000 Btu flow through a 1-in. pipe with a temperature drop of 20 F the velocity of the water will be 4½ in. per second in the 1-in. pipe.

Reference to Fig. 6 shows that for a velocity of 4½ in. per second and a friction head of 700 milinches, a 0.5 in. orifice must be used.

Similarly, the pressure head tending to force water through Radiator III is 1992 milinches higher than that tending to force it through Radiator I. If 1 in. pipe is used for the risers from Radiator II to Radiator III, the friction head in 24 ft. of 1-in. pipe will be 312 milinches. This, added to the friction head (288 milinches) in the 1¼-in. risers, gives a total friction head of 600 milinches and that subtracted from the excess available pressure head (1992) leaves a balance of 1392 milinches, which must be provided to prevent Radiator III from robbing the two lower radiators of a portion of their share of the water.

From Fig. 6 it appears that, for a velocity of 4½ in. per second and a friction head of 1392 milinches, a 0.45-in. orifice must be used in a union placed in the radiator connection. The experimental determinations described apply only to orifices in 1-in. pipe and the diagrams of Fig. 6 should be used only for orifices in 1-in. pipe.

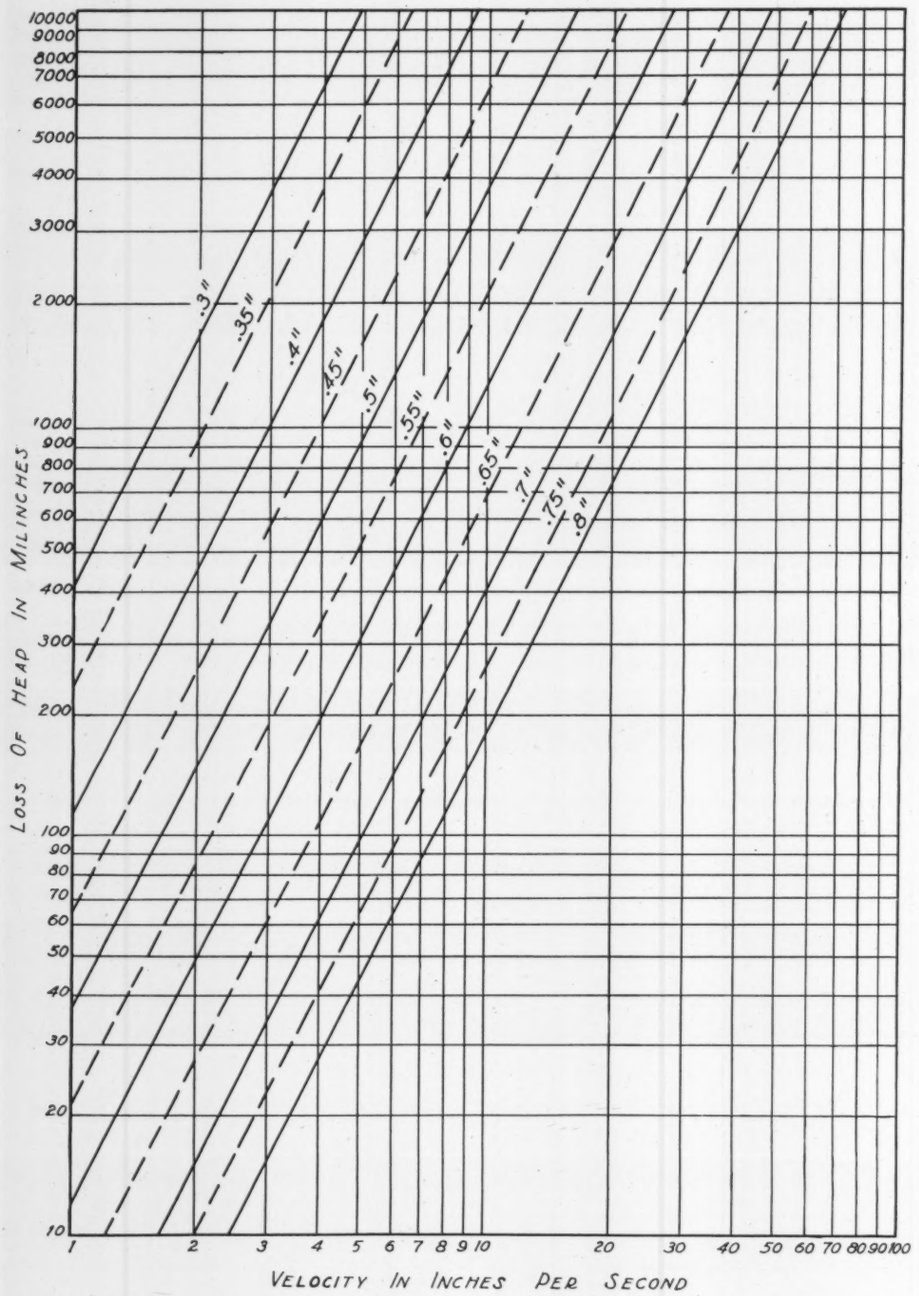

FIG. 6—LOSSES OF HEAD IN CENTRAL CIRCULAR DIAPHRAGM ORIFICES IN 1-IN. PIPE DERIVED FROM THE EXPERIMENTAL VALUES SHOWN IN FIG. 5

Discussion

To make this paper more nearly complete, and to check the accuracy of the results, Fig. 9 was added. The diagram of this figure shows the results secured with circular orifices in ¾-in. pipe in an investigation conducted by the Texas Engineering Experiment Station in co-operation with the A. S. H. V. E., and reported in the paper Pipe Sizes for Hot Water Heating Systems by Giesecke and Smith, presented at the Summer Meeting of the Society in 1929.

In order to compare the results of the two investigations made at different times and by different methods, the line *AB* of Fig. 9 was drawn to represent the loss of head in a 0.3 in. orifice determined graphically from the values shown in the diagram for ¼-in., 5/16-in., and ⅜-in., orifices by the method previously described and shown in Fig. 8.

A test was then performed to determine, experimentally, the loss of head in a 0.3 in. orifice in a ¾-in.

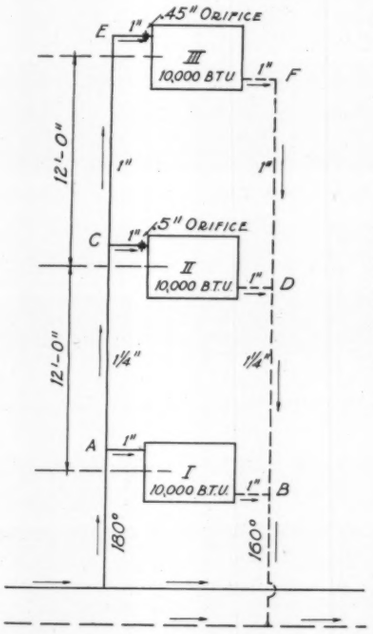

Fig. 7—A Section of a Heating System to Illustrate the Use of Orifices for Increasing Friction Where Necessary

pipe by the method used to determine the losses of head shown in Fig. 6 for orifices in 1-in. pipe; the results of this test fall so nearly on the line *AB* of Fig. 9 that it is impossible to draw a line through the points which differ materially from line *AB*. Since the losses of head for a 0.3 in. orifice determined by the two methods are practically identical, it is safe to conclude that both methods of determining losses of head in diaphragm orifices are reliable and that the results of both are sufficiently accurate for all practical purposes.

Finally, in order to compare the results of these investigations with those secured with circular diaphragm orifices in 4-in., 6-in., and 12-in. pipe and described in Engineering Experiment Station Bulletin No. 109 of the University of Illinois, the coefficients of discharge were calculated and the results recorded in Fig. 10. These coefficients were calculated as follows:

For a 1-in. pipe, a 0.5-in. orifice, and a loss of head of 6 in., the velocity of the water in the pipe is 12.5 in. per second, and the quantity flowing through the orifice is

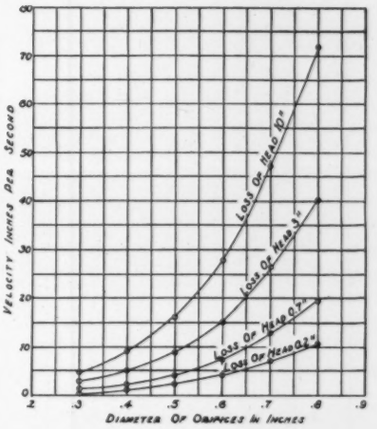

Fig. 8—A Diagram to be Used for Determining the Losses of Head from Those Shown by the Full Lines of Fig. 6

10.67 cu. in per second. The increase in velocity corresponding to a head of 6 in. is 68 in. and the resulting velocity is 12.5 plus 68 in., or 80.5 in. per second. The corresponding quantity of water which would flow through the orifice is 15.8 cu. in. per second. The coefficient of discharge is $\frac{10.67}{15.8}$ or 0.674 as shown in Fig. 10.

A large number of these calculations were made and it was found that the coefficient of discharge is practically independent of the velocity of the water but varies with the size of the pipe and with the ratio of the diameter of the pipe to that of the orifice, as shown in Fig. 10.

The variation with this ratio was found to be regular for orifices smaller than 0.8 in. when used in 1-in. pipe. The 0.8-in. orifice was evidently so large that its loss of head follows a different law from that governing the losses caused by the smaller orifices and this size should be excluded from a regular orifice table just as the 0.9-in. orifice was excluded in the earlier progress of this investigation.

A similar difficulty was experienced with the ⅜-in. orifice in the ¾-in. pipe. The investigations at the University of Illinois indicate that it is difficult to secure precise measurements when the diameter of the orifice exceeds two-thirds the diameter of the pipe.

The results shown in Fig. 10 for 1-in. and ¾-in. pipe

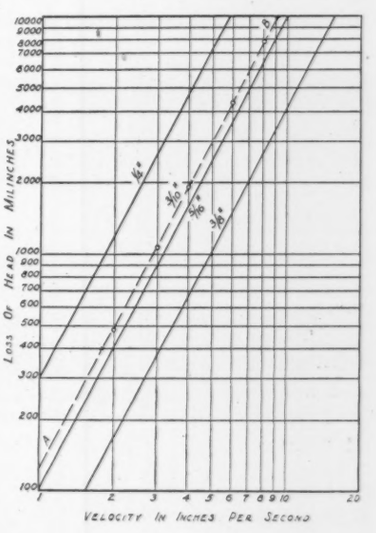

Fig. 9—Losses of Head in Central Circular Diaphragm Orifices in ¾-in. Pipe

are so similar to those shown in the University of Illinois Bulletin No. 109 for 12-in., 6-in., and 4-in. pipe, and reproduced in Fig. 10 by dotted lines, that it seems possible to determine the loss of head for any central circular orifice in any pipe with considerable accuracy by interpolation between the experimental values of these two investigations.

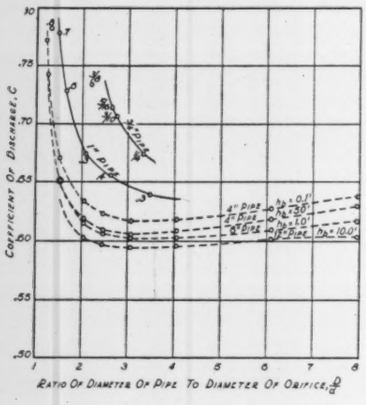

FIG. 10—A COMPARISON OF THE COEFFICIENTS OF DISCHARGE FOR CENTRAL CIRCULAR DIAPHRAGM ORIFICES IN ¾-IN. AND 1-IN. PIPE CALCULATED FROM THE VALUES SHOWN IN FIG. 9 AND FIG. 6 WITH THOSE FOR 4-IN., 6-IN. AND 12-IN. PIPE REPRODUCED FROM BULLETIN NO. 109, ENGINEERING EXPERIMENT STATION, UNIVERSITY OF ILLINOIS

Conclusions

The loss of head in submerged central circular diaphragm orifices in pipes varies materially with the size of the pipe and with the ratio of the diameter of the pipe to that of the orifice and only very slightly with the velocity of the water.

The losses can be determined very accurately and the resulting data used either to regulate the friction in a pipe line when the velocity is known or to determine the velocity and consequently, also, the quantity of water flowing through the orifice.

Acknowledgment

The experimental work was performed in the Mechanical Engineering Laboratory of Texas A and M College and the author is indebted to Prof. C. W. Crawford and Prof. A. V. Brewer of the Department of Mechanical Engineering, and to Prof. T. A. Munson of the Department of Civil Engineering for valuable cooperation.

All drawings and practically all calculations and all laboratory work incident to this investigation are the work of W. H. Badgett, graduate student and research fellow at Texas A and M College, assisted by G. W. Lewis, a senior student, and much credit is due them for the accurate manner in which their work was performed.

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Mechanical Analysis Chart Announced

A Mechanical Analysis Chart has recently been announced by *Fuel Oil Journal.* This chart lists 199 burners manufactured by 138 companies, and gives at a glance the following information: Method of atomizing or vaporizing oil for combustion; how air is obtained; method of ignition; how oil is fed; operation and control; grade of oil recommended and capacity range of burners. The chart is in one piece and folded so it may be opened to show every burner at a glance.

Production of Coal Increased in 1929

The world production of coal of all grades in 1929 was 1,540,000,000 metric tons, representing a gain of 6.2 per cent over 1928, according to preliminary figures compiled by the U. S. Bureau of Mines, Department of Commerce. Of the 1929 production, 229,000,000 tons, or about 15 per cent of the total, was lignite and 1,311,000,000 tons was bituminous coal and anthracite. In comparison with 1928 the output of lignite increased 5.5 per cent and the production of bituminous coal and anthracite 6.8 per cent.

The United States was the largest producer, its total output being 552,465,000 metric tons, of which 69,526,000 tons was anthracite and 482,939,000 tons was bituminous and lignite. The second largest producing country was Germany, credited with a total output of 352,156,988 tons; of this 163,437,056 tons was bituminous and 175,177,932 tons was lignite. Production in the Saar District from mines under French control was 13,542,000 tons.

Index to Coal and Coke Reports of Bureau of Mines

For the convenience of the coal trade, the U. S. Bureau of Mines has published an index to the weekly reports on the production and distribution of coal and coke and to the monthly reports on production of by-product and beehive coke issued during the coal year 1929-1930. The economic information regarding the coal and coke industries contained in these weekly and monthly reports is thus made much more readily available. The references cited include such items as relative growth of coal, oil and water power; world energy supplies; labor statistics; methods of mining; current trends of coal consumption; coal production by states; distribution of anthracite and bituminous coal, etc.

Control Equipment for Gas Burner Heating Appliances

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MEMBER

THE American household has become mechanized in recent years. The domestic establishment has gone automatic. Pressing a button has relieved the housewife of many arduous duties, and has given the whole family automatic entertainment during the evening hours. And now, as a crowning achievement, automatic heat has appeared, leaving nothing else needed to make an evening in an American home wholly automatic, unless it be an automatic bridge player.

Those words *automatic heat,* although applicable to heating as it is practiced in the industrial or commercial establishment, no less than to heating as practiced in the domestic establishment, have their greatest significance when applied to home heating. They symbolize the emancipation of the man of the house, his wife, and his servants, from the drudgery of tending the fire, and from the occasional discomfort at times when the manually-controlled fire fails to keep pace with the vagaries of the weather. Nothing contributes in a greater degree to home comfort than attention-disdaining heating, and nothing contributes in a greater degree to the absent husband's peace of mind than the knowledge that the heating plant will continue to function in his absence.

Adaptability to automatic heating is not the exclusive prerogative of a single fuel. Gas, oil and coal are being successfully mechanized on a domestic scale. It is not the purpose of this paper, however, to draw any comparisons between these different fuels for obtaining automatic heating, but rather to survey, in a brief manner, the means available and utilized for harnessing one fuel, gas, and for making it one of the fuels adaptable to automatic heating as practiced in the modern mechanized home.

Classification

Before considering the means by which control is secured, it may be well to consider the ends toward which those means are directed. The function of a controlling device as applied to a gas burning boiler or furnace is, in general, to regulate or to modify the rate at which the fuel is supplied to the main burners, in such a manner as either to maintain constant conditions, or to modify those conditions in accordance with a predetermined schedule. In order to accomplish that end the controlling means may be made responsive to certain independent variables, among which are:

1. Room temperature
2. Water temperature
3. Air discharge temperature
4. Outdoor temperature
5. Steam pressure
6. Gas pressure
7. Time
8. Pilot flame
9. Boiler water level

Certain of the controlling means responding to these variables may be designated as *operating* controls, some as *protective* controls, and some as both. The controlling means enumerated can be classified as follows:

OPERATING	PROTECTIVE
Room Temperature	Water Temperature
Water Temperature	Air Discharge Temperature
Outdoor Temperature	Steam Pressure
Steam Pressure	Pilot Flame
Gas Pressure	Boiler Water Level
Time	

As a general rule, each control, or each function of control, is accomplished through the coordinate action of a controlling means and an actuating means. Controlling means in general usage today may be classified as:

(a) Mechanically operated
(b) Gas operated
(c) Electrically operated

Descriptions of Controlling and Actuating Means

The action of a controlling means is invariably that of a valve which shuts off completely the flow of gas to the main burners of the boiler or furnace, or modifies or *modulates* it, and the controlling means itself is simply a gas valve with a construction that lends itself to actuation by some variety of actuating means. Fig. 1 illustrates a controlling means of the mechanical type; Fig. 4, one of the gas-operated type; and Fig. 9, one of the electrical type.

The valve shown in Fig. 1 is essentially a globe valve, with a soft, gas-tight seat. It is opened and closed by the raising and lowering of a stem projecting through a stuffing box in the valve bonnet, and extending up into a case containing the various operating levers. By an ingenious arrangement of levers and pins, upward and downward movements of the outer extremity of the *operating lever* serve to open or close the valve gradually. Actuating means responsive either in changes in steam pressure or in water temperature can be adapted to produce this movement. (See Fig. 3.) The *shut-off lever,* to the outer extremity of which a weight is hung, closes the valve completely when room temperature demands are satisfied. To permit the valve to open, the shut-off lever, with its attached weight, is held at the upper limit of its travel by a room-temperature controlled motor. Any standard make of room temperature thermostat capable of controlling a motor, can be used to raise and lower this lever. The motor can be attached

[1] Research Engineer, Bryant Heater and Mfg. Co., Cleveland, Ohio. Presented at the Semi-annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Minneapolis, Minn., June, 1930.

to the lever by a chain, or it can be mounted directly on a bracket attached to the valve.

Fig. 2 shows how this type of controlling means can be actuated by boiler water level. A float chamber, serving also as a water column, is attached to the boiler above and below the water line. A float within the chamber, rising and falling with the water level, when in the position corresponding to a normal water line permits a small crank supporting a weight to rest against a stop just beyond its vertical center. Dropping of the float, due to a subsidence in water level, causes the crank to be pushed through the small angle necessary to carry it away from the stop, and over center, whereupon the weight drops, depresses an extension of the valve stem, and closes the valve. On return of the water line to its normal level, the device may be reset, permitting the gas valve to be opened once more.

Fig. 1 shows the application of control by the pilot flame to this type of gas valve. A tube containing a volatile liquid is wrapped around a cup that surrounds the pilot flame. This tube is connected by a piece of capillary tubing to a bellows located within the compartment housing the valve-controlling levers. Pressure created in the tube and bellows by the presence of a flame at the pilot, within the cup about which the tube is wrapped, causes the bellows to expand. This expansion is sufficient to compress a spring which will allow the main valve to open in response to a demand for gas. Absence of flame at the pilot, and therefore absence of pressure in the bellows, keeps the valve from opening regardless of the condition of steam pressure, water temperature, or room temperature control.

Fig. 3 shows a gas burning steam boiler provided with mechanical control and also showing the different elements pointed out.

Fig. 4 represents a gas valve of the gas-operated type. This valve consists essentially of a valve body containing a machined seat and suitable gas passages, to which is assembled a valve cover and a valve diaphragm which carries a valve disc. The valve contains in effect two chambers, separated by the diaphragm. The diaphragm

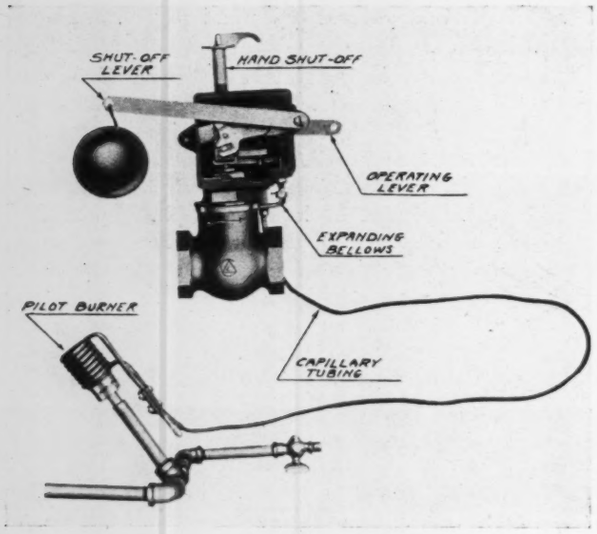


Fig. 1—Mechanical-Type Gas Valve Showing Thermostatic Pilot Burner

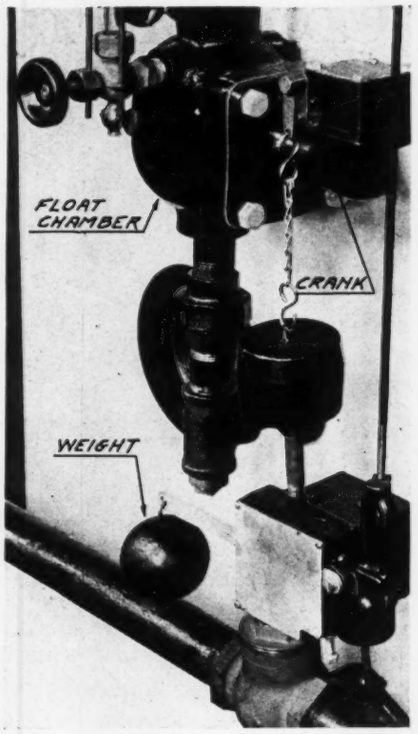


Fig. 2 — Mechanical-Type Low-Water Control

is made of sheep-skin, extremely flexible, tanned by a process that makes it highly resistant to the action of the constituents of gas, and thoroughly impregnated with oil. The operation of the valve is due to differences produced in the pressures exerted on the upper and lower sides of the diaphragm. With gas pressure beneath the diaphragm and atmospheric pressure above it, the diaphragm with its valve disc will be raised, allowing gas to pass through the valve. If, on the other hand, gas equal in pressure to that beneath the diaphragm and passing through the valve is allowed to fill the upper chamber, the total pressures above and below the diaphragm become equal and the diaphragm and valve disc fall due to their own weight, thus stopping the flow of gas. With the valve seated, the area exposed to gas pressure on the upper side of the diaphragm becomes much larger than that so exposed on the lower side, and the valve is held firmly seated by the preponderance of total pressure on the lower side.

There are two or three modifications of this construction in use, but the operating principles of the different types are practically identical. The construction shown in Fig. 4 is used in the major proportion of such valves.

To actuate this type of valve in response to changes in such conditions as boiler pressure, water temperature, water level, pilot flame, etc., it is only necessary that the changing conditions open or close a small valve which will admit gas to the upper chamber of the diaphragm valve when it is desired to close it. Conversely, the changing conditions must close this small valve when it is desired to have the diaphragm valve open. Fig. 5 shows an actuating means responsive to changes in steam pressure or water level. This device is connected to the steam boiler, above and below the water line and serves also as the water column. The small valve at the top of this assembly is opened either by increasing steam

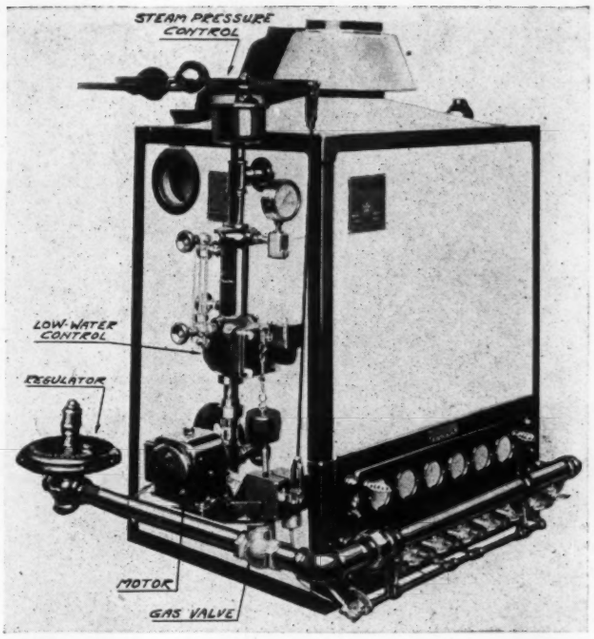


FIG. 3—STEAM BOILER WITH MECHANICAL CONTROL

pressure, which compresses the bellows against the resistance of the movable weight on the arm, or by receding water level which operates through the agency of the hollow float and suitable connecting parts. Fig. 6 shows an actuating means responsive to changes in water temperature. The unequal expansions of a copper tube immersed in the water, and an alloy rod enclosed in the copper tube, operate to open or close a small gas valve that is a part of the assembly, thus closing or opening the diaphragm valve. Fig. 7 shows a pilot burner which includes a feature that makes it necessary for the pilot to be burning in order to permit the diaphragm valve to open. A bi-metallic strip, when heated by the pilot flame, permits the small gas valve that is a part of the pilot burner assembly to remain closed. Cooling of this strip, due to accidental extinguishment of the pilot, opens the small valve, permitting gas to reach the upper chamber of the diaphragm valve, thus closing it. This feature prevents wasting of unburned gas in the remote event of a pilot being accidentally extinguished.

The device shown in Fig. 6 can with very few changes be used to control or limit the temperature of the air being discharged by a warm air furnace. The copper tube enclosing the alloy rod is inserted within the bonnet of the furnace and serves to prevent over-heating of the furnace in the event of circulation of air becoming restricted from any conceivable cause. For controlling the room temperature any of the usual varieties of room temperature thermostats can be used to actuate a small magnetic valve, which when open will permit gas to enter the upper chamber of the diaphragm valve.

The diaphragm valve can, if desired, be arranged so as to close gradually in response to increasing steam pressures, instead of closing completely when a predetermined maximum pressure is reached. On some classes of steam heating systems, this method of operation is advantageous. Fig. 8 shows a gas-burning steam boiler provided with diaphragm valve control, with the different elements pointed out.

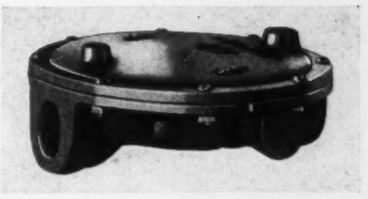


FIG. 4—GAS VALVE OF GAS-OPERATED TYPE

Electrical controls are, as their name implies, dependent on electrical current for their operation. The most usual type of electrical gas valve is shown in Fig. 9. It consists essentially of a globe valve body, with a rising stem carrying a rack which engages a pinion on the shaft of a small motor. Rotation of the motor, due to the completion of the operating circuit, draws the valve to the upper limit of its travel, whereupon the motor stalls and holds the valve open so long as the electrical circuit is complete. Breaking of the circuit, which may be caused by the action of room or water temperature thermostats, steam pressure controls, water level controls, or pilot burner thermostats, will cause the valve to close through spring action. The thermostats and other actuating devices used for this purpose are of comparatively well known construction.

One piece of control equipment that is common to all completely equipped gas-burning heating devices is a gas pressure regulator, shown in Fig. 10. The purpose of the regulator is to maintain a constant gas pressure at the burner orifices, regardless of variations in the pressure at which the gas reaches the premises. These variations in pressure are sometimes quite pronounced, particularly in the natural gas regions. Since there is one rate of gas supply at which the appliance will be delivering maximum efficiency and at the same time be burning the gas completely, it is essential that this one rate be maintained in spite of any fluctuations there may be in the street pressure. All gas burners are equipped with some form of metering orifice, so that by controlling the pressure on the inlet side of the orifice, the rate of gas flow may be controlled accurately.

The usual regulator is of the diaphragm type, with the diaphragm supporting a balanced valve. The pressure on the outlet side of the balanced valve (the regulated

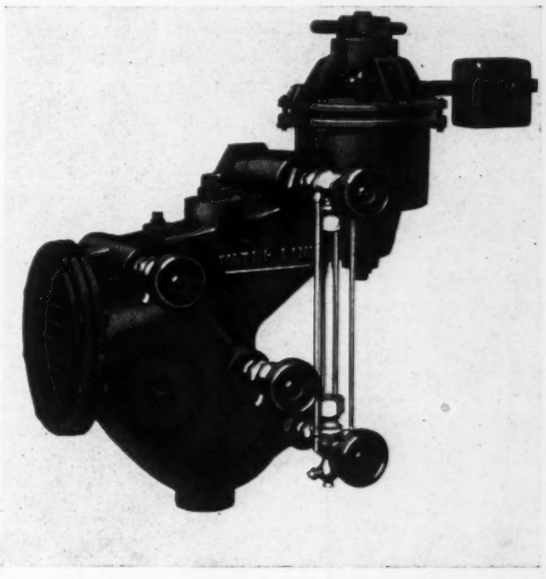


FIG. 5—GAS-OPERATED STEAM PRESSURE AND LOW WATER CONTROL

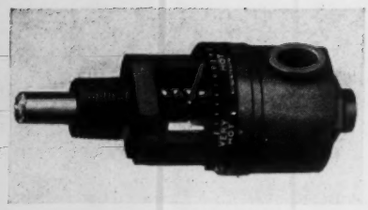


FIG. 6—GAS-OPERATED WATER TEMPERATURE CONTROL

pressure) is conveyed to the lower side of the diaphragm. The diaphragm and valve are loaded by a spring, and regulation is accomplished by virtue of a balance of pressure being secured between the gas pressure on the lower side of the diaphragm and the spring pressure above the diaphragm. By varying the initial compression of the spring, the outlet gas pressure may be adjusted, and once adjusted it will remain constant to within a very small percentage, regardless of inlet pressure variations.

Appliance and System Performance as Affected by Controls

The effect of a controlling device on appliance or system performance may be considered in two lights, (1) the effect on the comfort of those persons who are living in the atmosphere created by the heating system, and (2) the effect on the overall economy of the heating system, the overall economy including not only the bare cost of fuel but also the fixed charges on the investment and such service costs as are involved. On the one hand, there is an effect which is revealed only by the bodily sensations, and on the other, the price paid for that effect. As a general rule, so far as gas-burning heating appliances are concerned, the effect of a controlling method on fuel cost, that is, on appliance or system efficiency, is very small. After a gas-burning heating system is put under the primary control of a thermostat which maintains a substantially constant temperature within the heated space, the application of further controlling devices will produce very little change, in either direction, on the ratio of gas consumption to heating demand. The question thus becomes one of balancing the beneficial effect of a more or less complicated controlling arrangement against the fixed charges attributable to the first cost of the arrangement and the added service, maintenance, and engineering

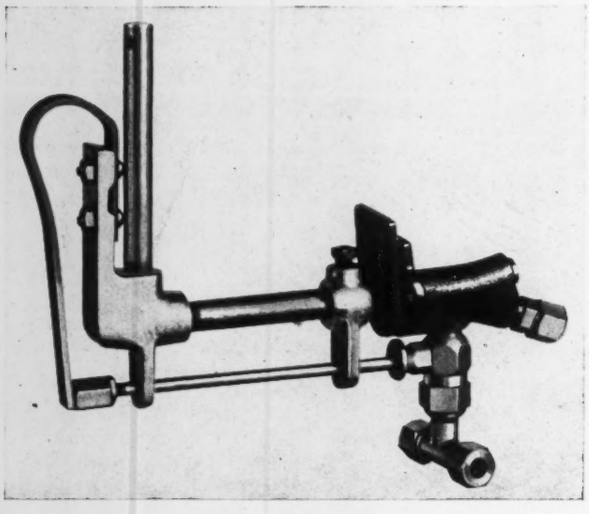


FIG. 7—THERMOSTATIC PILOT BURNER

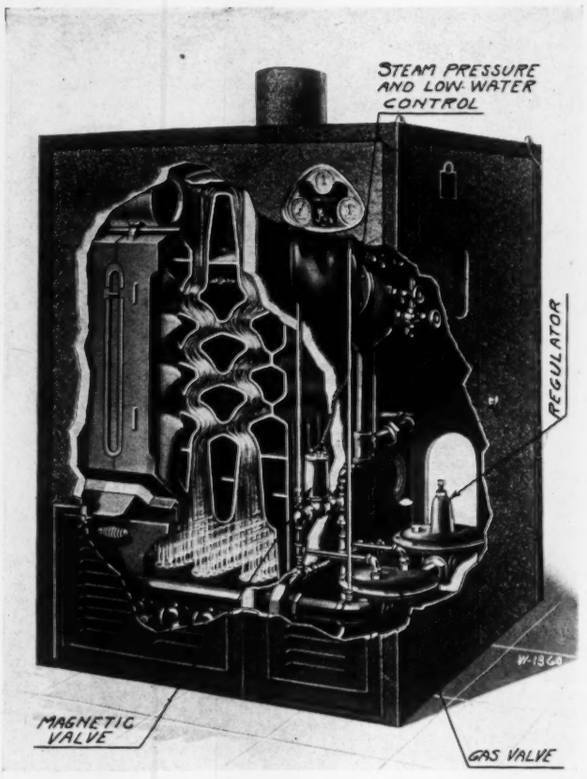


FIG. 8—STEAM BOILER WITH GAS-OPERATED CONTROL

costs. It is the writer's opinion that in many cases where attempts are made to correct faults in heating by the application of special controlling devices, the trouble might better have been attacked at the source, which is more often found in the heating distributing system than in the heat generating apparatus.

FIG. 9—ELECTRICALLY-OPERATED GAS VALVE

There is no need of discussing the effect of room temperature control on fuel economy. With an average heating season temperature of 35 F, and a desired indoor temperature of 70 F, each degree in excess of the desired 70 F means an addition of almost 3 per cent to the heat loss and therefore to the fuel consumption. A control, such as a room thermostat, maintaining a temperature that is in excess by a minimum amount of the lowest temperature compatible with bodily comfort, leads to maximum fuel economy. The question of whether clock control of room thermostats, whereby a reduced temperature is maintained during certain hours, results in increased fuel economy, has received a great deal of discussion. The writer has proved to his own satisfaction that in at least one type of residence construction, the maintenance of a reduced temperature during the night hours produces a definite fuel saving. This is by no means a universal and conclusive answer, however, because the possible creation of a peak demand on gas distributing systems during the heating-up period in the early morning, as well as the possible service calls chargeable to the clock, must also be considered.

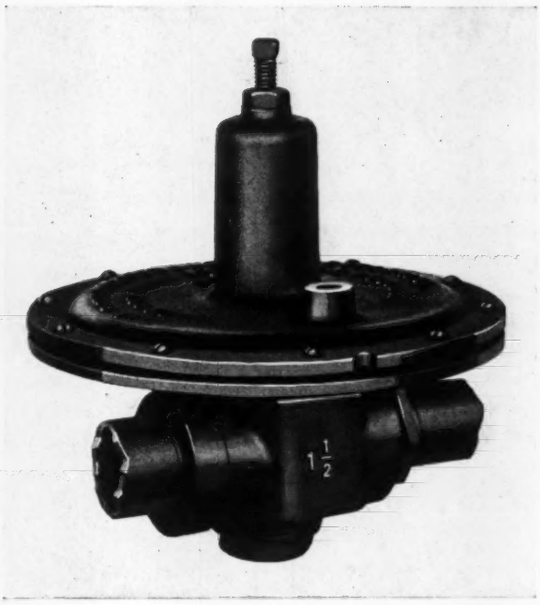


FIG. 10—GAS PRESSURE REGULATOR

It has already been pointed out that the automatically-controlled gas valve may either shut off the flow of gas to the main burners completely, or shut it off only partially, by throttling or partially closing the gas valve in response to pressure or temperature changes. Arguments as to the effect on appliance efficiency of intermittent burner operation at full gas supply rate against steady operation for longer periods at a reduced gas supply rate are to no avail. Although a gas appliance operates at its maximum efficiency when it is burning gas at the rate for which it is designed, since at that rate the proper proportion of secondary air is drawn into the flame, the reduction in efficiency with a reasonable reduction in gas rate is so small as to be academic rather than real. The superiority, if any, of either method of gas control must be looked for in its effect on appliance operating characteristics and on the comfort of those living in the heated premises.

FIG. 11—ELECTRICALLY-OPERATED AIR TEMPERATURE CONTROL

This paper has touched the subject of gas boiler and furnace controls in a very sketchy manner. It has not attempted to present any of the numerous ramifications in control arrangements which may be resorted to in order to secure special effects. It is limited to a very general consideration of only those varieties of control which may be regarded as standard, and these standard varieties of control have demonstrated their adequacy to handle at least 99 per cent of all the gas appliance control problems encountered.

New Illinois Engineering Experiment Station Building Dedicated

On Friday and Saturday, May 2 and 3, the University of Illinois celebrated the 25th anniversary of the founding of its Engineering Experiment Station. This station, one of the first of its kind in this country, was really established 27 years ago, but actual operation was not begun until two years later.

The new experiment station building at Illinois was formally dedicated at a session Friday morning with addresses by Professor Talbot, Dr. Abbott, Professor White, and President Kinley. Professors Talbot and White recounted the growth of the organization, service and physical plant of the station. Drs. White and Kinley honored the founders of the station, among whom were Professors Talbot, Baker, Breckenridge, and Parr, and expressed their commendation of the achievements of the station during the past quarter of a century.

Various members of the station staff briefly described the projects in which they are or recently have been engaged. These cover a very wide field and include some notable problems, such as their study of the ventilating of the Holland Vehicular Tunnel, of which Prof. A. C. Willard was consulting engineer on ventilation, their comprehensive study of stresses in railroad track, and their notable achievements in the fields of repeated stresses, coal utilization, and concrete construction.

Over 30 states have during the past 25 years established stations after the model at Illinois.

Rate of Pure Carbon in Air

The specific surface reaction rate of pure carbon in air has been measured with remarkable reproducibility by scientific workers of the Pittsburgh Experiment Station of the U. S. Bureau of Mines, Department of Commerce, and of the Carnegie Institute of Technology. This information is important in the burning of solid fuels such as coal and coke. Fundamental information on this chemical reaction has been difficult to obtain because of the difficulty of adequately controlling the important factors of oxygen concentration, area of reacting surface, and surface temperature. When a piece of carbon starts to burn vigorously the surface area changes rapidly, the surface temperature quickly gets out of hand and the concentration of available oxygen rapidly decreases. And, as is often remarked in scientific work, unless all influencing factors are not either known at all times or kept constant, fundamental information cannot be obtained. The new method involves bringing accurately shaped and weighed spheres of carbon to a known temperature in an inert gas, suddenly blasting the particle with an air stream of known velocity and temperature for a very short interval, quickly quenching the particle in inert gas, again weighing to determine the amount of reaction, and obtaining careful records of the particle surface temperature during the combustion. The results are highly reproducible and should be of real value in the design and control of coal- and coke-burning installations.

Local Chapter Reports

Cleveland

May 26, 1930: In the absence of Pres. W. C. Kammerer, the meeting was called to order by F. H. Morris, vice-president of the Cleveland Chapter.

The report of the Nominating Committee was read by the secretary and on motion by J. J. Mason the report was accepted unanimously without further discussion. The officers for the year 1930-31 were elected as follows:

President—F. H. Morris
Vice-President—A. R. Bruggeman
Treasurer—H. M. Nobis
Secretary—R. G. Davis

Board of Governors—W. C. Kammerer, J. J. Mason and T. A. Weager.

The members and guests were honored by having as guests the president of the Society, L. A. Harding, and also F. C. Houghten, Director of the Society's Research Laboratory in Pittsburgh.

President Harding gave a very interesting talk on the Utilization of the Sun's Energy, which he illustrated with lantern slides, while Director Houghten spoke on Heat Absorption from Solar Radiation, both addresses being thoroughly enjoyed.

On motion of C. F. Eveleth, the Chapter expressed its appreciation to both President Harding and Director Houghten for honoring the Cleveland Chapter with their presence and making the meeting such an enjoyable one for the members and guests present.

Michigan

May 14, 1930: The Michigan Chapter of the Society held the final meeting for the 1929-30 season on Wednesday, May 14, at the Hawthorne Valley Golf Club, with 63 members and guests in attendance.

About 50 members entered the Golf Tournament and the fortunate ones were, H. A. Schwartz, who received first prize, E. McFate, second prize and W. A. Rowe, third.

R. J. Roach and M. B. Shea tied for high score. The kicker's handicap prizes were awarded to W. A. Rowe, I. W. Gates, H. A. Schwartz, A. J. Maguire and Fred Davis.

Two baseball teams were captained by J. L. Fuller and W. J. Whelan, respectively. Mr. Fuller's team won, the score being 26-25.

After the golf and baseball athletes had returned to the 19th hole, an event of great importance was announced and the awarding of the Grand Prize was made to John S. Kilner, who received a Ford "car." The fact that this "car" was built in 1918 and retails today at a price of $10.00 a copy, was not definitely specified before the award was announced.

After dinner W. A. Rowe presided and the election of officers took place. The following were elected for the year 1930-31.

President—E. E. Dubry
Vice-President—R. K. Milward
Secretary—E. H. Clark
Treasurer—W. J. Whelan

Board of Governors—G. H. Giguere, L. L. McConachie and N. B. Hubbard.

E. E. Dubry, the newly elected president, then asked the members for the same cooperation which was extended to his predecessor, W. G. Boales. At this time it was unanimously requested that the Secretary write to Mr. Boales and extend to him the entire Chapter's vote of thanks for the work which he did, not only while he was president of the Chapter, but during the entire period of time that he was located in Detroit.

The meeting was adjourned about 11:00 o'clock.

New York

May 12, 1930: One of the big meetings of the year was held at the Building Trades Employers Club, New York, and the annual entertainment program for the 125 members and guests was provided by Alfred Engle.

A few announcements and matters of routine business were quickly disposed of and E. J. Ritchie, concluding his term as president, introduced President-elect A. J. Offner, and turned the gavel over to him.

After a good dinner an appreciative audience was ready to enjoy the vocal and musical numbers rendered by the orchestra and leading vaudeville artists.

Western New York

May 12, 1930: Kentucky Night, an annual feature of Western New York Chapter programs, was held in the Ball Room of the Hotel Statler on May 12 in honor of Dean F. Paul Anderson and his University of Kentucky Senior Class of Engineers. The largest gathering of members and guests of the year was on hand when Fletcher H. Burke, president of the Chapter, opened the meeting.

The University of Kentucky was represented by Dean F. Paul Anderson, Dean of the College of Engineering, W. E. Freeman, Assistant Dean, L. S. O'Bannon, Professor of Steam Engineering, J. B. Dicker, Superintendent of Shops, head of Department of Practical Mechanics, and the president of the Senior Class, John C. Benson.

In behalf of the mayor of the city of Buffalo, George F. Fisk, Commissioner of Public Works, welcomed the Kentucky representatives to Buffalo, offering them the freedom of the city.

L. A. Harding, President of the Society, C. W. Farrar, Treasurer, and Roswell Farnham, a member of the council, were among the officers of the Society who were present.

After a brief talk from each of the officers President Burke called upon the President of the Buffalo Engineering Society, Henry Rexinger, then on C. A. Booth, Fred Zander, W. H. Trask, Ralph Coe, Dean Anderson and Mrs. Olive E. Frank, each in turn saying a few words.

J. W. Pennel responded for the Kentucky engineers and his wit and pleasant personality won the entire audience.

The speaker of the evening was Samuel B. Botsford, Executive Vice-President of the Buffalo Chamber of Commerce, who gave an inspiring and comprehensive address, which was followed by adjournment.

April 12, 1930: About 75 members and guests gathered in the Grill Room of the Hotel Buffalo for the April meeting of the Western New York Chapter.

Following the dinner which preceded the meeting, Roswell Farnham outlined the plans for the Semi-Annual Meeting at Minneapolis.

The Chapter was privileged to hear one of the most interesting and instructive lectures when Prof. J. H. Curtin of D'Youville College, spoke on The Sun, the Big Furnace of Little Earth, or the Source of All Energy, which he illustrated with stereopticon slides of solar views, most of which he had photographed himself from his observatory at High Point, N. Y.

Professor Curtin is a scientist and astronomer of interna-

tional reputation, and his talk held the listeners' attention for two hours.

After a rising vote of thanks was extended to Professor Curtin for rendering such an interesting talk, the meeting was adjourned.

St. Louis

June 2, 1930: The St. Louis Chapter of the Society held its regular monthly meeting at the Roosevelt Hotel, June 2, with an attendance of 39 members and guests.

The minutes of the previous meeting were read by the Secretary. E. B. Langenberg called attention to the fact that these minutes did not mention the meeting of Dean Anderson and Jerry of the Langenbreg household, the same being the son of the famous Jerry of the University of Kentucky. With this correction, the minutes were approved.

Being Ladies' Night, the usual order of business was taken care of as promptly as possible, after which President White called on Homer Linn of Chicago, who spoke on Home Modernization. Mr. Linn stressed the fact that the three most important elements about a home that must be modern are heating, plumbing and lighting.

At the conclusion of his address, Mr. Linn was given a rising vote of thanks.

The meeting was then turned over to the Entertainment Committee who arranged for a bridge game which lasted about two hours, there being two prizes for each table.

The meeting adjourned about 11 o'clock, and the members and guests of the St. Louis Chapter will not meet again until the fall when the annual outing will be held.

Wisconsin

June 9, 1930. The June meeting of the Wisconsin Chapter of the Society being the last one of the season, until September, was held in the form of a picnic at Wulf's Island, located about ten miles north of Milwaukee, with 36 members and guests attending.

The annual baseball game was the first thing on the program, with Captain John Jung's team defeating Captain A. M. Freeman's nine by the score of 23 to 19.

After the ball game the horse shoe tournament was started, and the lucky ones were Frank Glas, who won first prize, which was a pen and slide rule, and A. De Rycke, who received a fountain pen as a reward.

Immediately after the tournament dinner was served, which was followed by card games lasting until midnight.

From the standpoint of both attendance and a good time, this picnic stands out as one of the most successful the Chapter has ever had, all the arrangements being made under the guidance of John Jung, *Chairman* of the Picnic Committee, assisted by A. M. Freeman and E. A. Knab.

May 17, 1930. The regular monthly meeting of the Wisconsin Chapter of the Society was held at the Elks Club, Milwaukee, on May 17, with an attendance of 26 members and guests, presided over by Pres. F. G. Weimer.

J. H. Volk was appointed by President Weimer as chairman of the Nominating Committee, with A. M. Freeman and C. H. Randolph assisting him.

The guest speaker of the evening was F. C. Houghten, Director of the Research Laboratory of the American Society of Heating and Ventilating Engineers.

Mr. Houghten spoke of the Laboratory being ten years old, and showed how the great improvements in the heating and ventilating field in the past few years were reflected in the development of The Guide since 1922.

He then told of the origin of the Research Laboratory and the method of managing and maintaining it, and also explained that the Laboratory had never tested manufactured devices for manufacturers, but that in 1924 the rules were revised to permit such testing under certain conditions. A resumé of the work done by the Laboratory in developing the standards for ventilation, one of the earliest problems of the Laboratory and still its biggest one, were cited by Mr. Houghten.

A rising vote of thanks was then given to Mr. Houghten for his interesting talk on the Society's Research Laboratory, and shortly after the meeting was adjourned.

Presentation Made to L. A. Harding

A group of friends of L. A. Harding, President of the Society, gathered at the Hotel Statler, Buffalo, on May 14, where a dinner in honor of Mr. Harding was held.

The duties of toastmaster were in the capable hands of Robert J. Summers, and the speakers who paid tribute to Mr. Harding were Richard C. O'Keefe, John W. Cowper and F. Paul Anderson, dean of engineering at the University of Kentucky.

At the conclusion of the entertainment program and the various speeches, Gordon Steele presented Mr. Harding with a set of matched golf clubs, and Park L. Metzger gave the guest of honor a platinum watch charm bearing the insignia of the *Associated General Contractors.*

Among the 40 guests present were C. W. Farrar, Treasurer of the A. S. H. V. E., Roswell Farnham, member of the Council of the Society and A. V. Hutchinson, Secretary, R. H. Tifft, President of the University Club of Buffalo and George F. Fisk, Commissioner of Public Works.

Numerous messages from other friends together with a scroll signed by all who were present were presented to Mr. Harding.

Philadelphia Chapter Presents Memory Book to Thornton Lewis

On May 8 the Philadelphia Chapter held its Annual Meeting at the Torresdale-Frankford Country Club. One hundred members and guests were present at dinner when an unexpected feature of the program was the presentation to Thornton Lewis of a handsome leather bound book containing the published record of his administration while president of the American Society of Heating and Ventilating Engineers.

Pres. Harry Black introduced F. D. Mensing, who made the presentation speech.

It was a complete surprise to Mr. Lewis and he expressed his gratification to the members for their kind remembrance and said that this volume would be one of his most prized possessions.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the name of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Membership Committee as soon as possible.

When the Membership Committee has acted favorably upon a Candidate's application and assigned his grade the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 7 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by July 15, 1930, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary, immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
Earhart, Joseph Stanley, Sales Engineer, English & Lauer, Inc., Los Angeles, Calif.	L. H. Polderman A. H. Simonds	R. L. Gifford H. P. Gant
English, Harrold, Pres., English & Lauer, Inc., Los Angeles, Calif.	L. H. Polderman A. H. Simonds	R. L. Gifford H. P. Gant
Gille, Hadar B., Partner, Hugo Theorells Ingeniorsbyra, Stockholm, Sweden.	P. D. Close Hugo Theorell	W. H. Driscoll
Kendall, Edwin H., Sales Engr., English & Lauer, Inc., Los Angeles, Calif.	L. H. Polderman A. H. Simonds	R. L. Gifford H. P. Gant
Lauer, Harold B., Vice-Pres., English & Lauer, Inc., Los Angeles, Calif.	L. H. Polderman A. H. Simonds	R. L. Gifford H. P. Gant
Lewis, Carroll E., The Lewis Corp., Inc., Minneapolis, Minn.	Albert Buenger H. E. Gerrish	H. J. Sperzel H. G. Helstrom
Milliken, Vincent Dewey, Skidmore Corp., Chicago, Ill.	S. R. Lewis H. F. Maier	F. H. Sprague J. W. Mathis

Candidates Elected

In past issues of the Journal of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Membership Committee and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. II, Sec. VIII, of the By-Laws, the following list of candidates elected:

MEMBERS

Bailey, W. Mumford, Co-Partner, British Trane Co., London, England.

Barnum, Marvin C., Wilcolator Co., Newark, N. J.

Bond, Horace A., Manager, Warren Webster Co., Albany, N. Y.

Brissette, Leo A., Treas. and Gen. Mgr., Trask Heating Co., Boston, Mass.

Bullock, Thomas Anthony, Densmore LeClear & Robbins, Boston, Mass.

Carson, Clifford Clyde, Skinner Bros. Mfg. Co., Inc., St. Louis, Mo.

Conley, Walter J., Ames Iron Works, Philadelphia, Pa.

Kelly, Jerome J., Vice-Pres., Wisconsin Equipment Co., Milwaukee, Wis.

Love, Harold G., Weiss & Neistadt, Chicago, Ill.

Manning, Walter M., Heating Engr., Wigman Co., Sioux City, Iowa.

McKelvey, David Mitchell, Consulting Engr., 60 East 42nd St., New York, N. Y.

Murphy, William W., Treas., W. W. Murphy Co., Springfield, Mass.

Myers, George W. F., Mgr., York Heating & Ventilating Corp., St. Louis, Mo. (*Advancement*)

Norris, William Dauncey, The John R. Kehm Co., Chicago, Ill.

Olson, Gilbert E., Vice-President, Olson Bros., Omaha, Nebr.

Pelletier, Albert, S. R. Lewis, 407 So. Dearborn St., Chicago, Ill.

Phipps, Frederick George, C. A. Dunham Co., Montreal, P. Q., Canada.

Rose, William Kendall, Chief Engr. & Gen. Mgr., Chase Co., Ltd., London, England.

Schall, Howard Sheafer, Mgr., Erie Engrg. Bureau, Buffalo, N. Y.

Sonneborn, Charles, Shaw-Perkins Mfg. Co., West Pittsburgh, Pa.

Spofforth, Walter, Chief Engr., Ancker Hospital, St. Paul, Minn.

Sprague, James F., Pres., Sprague Engrg. Co., Milwaukee, Wis.

Sullivan, Tim J., Mgr., Sullivan Valve & Engrg. Co., Butte, Mont.

Urdahl, Thomas Harold, Consulting Engr., 1010 Vermont Ave., N. W., Washington, D. C.

Van Court, Walter Gearing, Heating Engr. & Field Supt., Wm. H. Lutton Co., Jersey City, N. J.

Viessman, Warren, Bureau of Mechanical-Electrical Service, Baltimore, Md.

ASSOCIATES

Case, Walter George, Tech. Mgr., National Radiator Co., Ltd., Hull, England.

Eiss, Robert M., Sales Engr., Buffalo Forge Co., Minneapolis, Minn.

Ferguson, Thomas, Warden King, Ltd., Toronto, Ont., Canada.

Gallivan, John M., Arthur E. Jones Co., Buffalo, N. Y.

Grieves, Thomas R., Branch Mgr., U. S. Radiator Corp., Buffalo, N. Y.

Guilford, Frederick William, A. Harvey's Sons Mfg. Co., Detroit, Mich.

Ine, Frank H., Mgr. of Htg. Div., Young Radiator Co., Racine, Wis.

Krenz, Alfred S., Wisconsin Equipment Co., Milwaukee, Wis.

Kuehnert, Albert C., Wichita Gas Co., Wichita, Kans.

Partridge, George Allen, Sales Engr., Herman Nelson Corp., Moline, Ill.

Ruff, Daniel Haines, Jr., Acme Tin Plate & Roofing Supply Co., Philadelphia, Pa.

Summers, Ernest Trevor, Cotter Bros., Winnipeg, Manitoba, Canada.

JUNIORS

Burk, C. Franklin, Sheldons, Ltd., Galt, Ont., Canada.

Hammond, Martin Joseph, Manager, American Heating Co., Long Branch, N. J.

MacKenzie, Donald Westerman, Holland Furnace Co., Pittsburgh, Pa.

Riesmeyer, Edward Henry, Jr., Foreman, Schaffer Heating Co., Pittsburgh, Pa.

Tichenor, Leslie R., Jr., 1235 Salem Ave., Hillside, N. J.

Heating · Piping and Air Conditioning EDITORIALS

"Elimination of Waste" Campaign

A national movement for elimination of waste has come from the Federal government, through bureaus, committees and national associations and has now started to function in the industrial field in the Elimination of Waste committee sponsored by the *American Society of Mechanical Engineers,* the *Society of Industrial Engineers, American Management Association, National Association of Cost Accountants* and the *Taylor Society.*

Waste is common in all industries. It has been stated frequently by economists that the United States is the most wasteful nation in the world. It has been stated that an Asiatic population of equal number could live comfortably on what the inhabitants of the United States throw away. It was stated at a meeting of the Elimination of Waste committee that the yearly cost of waste is unbelievable, staggering and beyond comprehension. The United States Department of Commerce estimated recently that there was a total waste in this country of 8 to 10 billion dollars or approximately 65 to 80 dollars per capita. It is alleged that this is a chief factor in the high cost of living.

The heating, piping and air conditioning industries are not excepted. They also have been charged with wasteful practices, not only in the erection of equipment but also in the operation and maintenance of that equipment. A few days ago a letter was received from an engineer of national repute in which he made the statement that in the maintenance and operation of mechanical equipment of office buildings, apartments, hotels, hospitals, factories and industrial plants, very little thought is given to strict economy.

It is not proposed by anyone connected with this nation-wide movement to lower the standard of living of the American people or to lessen the quality of its products. It is believed, however, that it is possible, through economy, to place the nation in a position of permanent prosperity and it is stated as an obvious fact that the most productive method for promoting economy is a study of engineering practice.

Piping, heating and air conditioning is charged with waste in sizing of pipes, in the weight and strength of flanges and fittings, in the fabrication and erection of ventilating ducts and, in fact, in many departments of its fields of operation. It was an economic move when the *American Society of Heating and Ventilating Engineers* published its Code of Minimum Requirements. Every article published in HEATING, PIPING AND AIR CONDITIONING is virtually a story of how to do work more efficiently and economically.

The time has come when the consulting engineer, the maintenance engineer and the contractor in heating, piping and air conditioning should study as never before the physical laws governing the operation and maintenance of equipment he specifies, operates or installs to the end that, in cooperation with this nation-wide movement, prosperity on the sound basis of service may be established in the United States.

Smoke and Fumes—A Problem

A deep concern to solve the smoke problem in our larger communities has manifested itself for years. Fumes, which are not usually so evident, have previously caused little thought, but are now known as the source of many civic and human difficulties.

Almost every article on the subject dwells on the damage caused by smoke and fumes. Tangible evidence is also submitted of specific cases of damage. It is not difficult to obtain reams of such evidence in large industrial communities. Many cities and towns succeed in passing smoke ordinances which are well-enforced for a time and then die the usual death of all laws which do not hold popular support.

When one has reviewed the literature on the subject and has considered the results so far achieved, there is one conclusion which is unavoidable. No real progress will be made in the elimination of smoke and fumes until definite information is at hand on the actual cost of such pollution. With this data at hand it will be possible to educate the public with facts. Then and only then will it be possible to obtain the financial means by which these evils can be fought. Air pollution studies made so far are a step in the right direction.

Just a few of the losses which we suffer at present from these causes include decreased illumination, increased death rate from pneumonia and allied diseases, suffering from "hay fever," asthma, bronchitis, sinus, etc.; expense of washing and cleaning, rapid deterioration of textiles, foodstuffs and even machinery, losses in plant life, and the health-giving effect of the sun's rays which would normally reach us if the atmosphere were clear. Surely these are

items which can be evaluated in dollars and cents.

At present, planning commissions are working on many problems of cities in various sections of our country. Practically every one of these commissions comes face to face with this problem of smoke and fumes. Some have already called in the aid of medical, chemical and air conditioning authorities to help solve these problems or to formulate a method of attack by which the problems may be eliminated. It would seem that this is a logical method of finding a solution, since each of these professions has a vast experience from which can be drawn ideas of value.

In the meantime would it not be of considerable value if the subject of the elimination of smoke and fumes were discussed in the technical press more fully and if the national societies of the medical, chemical and air conditioning fraternities were to hold symposiums on the subject in order to obtain helpful information?

Heat and Electricity

It has been suggested that the cause of the accumulation of "atmospheric electricity" should be studied, with a view of controlling or preventing it within enclosures where so-called "static discharges" often prove troublesome, and sometimes dangerous. This is sound logic, but the fundamental principles of the whole phenomenon are so little understood at present that any consideration must be largely speculative.

Modern science has largely abandoned the "ether" hypothesis in connection with the transference of light and heat, and recent investigations in the realms of physics have proved that the atom is in reality largely an accumulation of electricity. The things we can see and feel, and which are apparently solid matter, may be very far from solid.

Some physicists contend that matter is an aggregation of electrical particles—that the "elements" are simply groups of atoms composed wholly of nothing more substantial than that mysterious thing which we now refuse to call even "a subtle fluid." However, others at least equally eminent hold that the atom is composed of two or more particles of matter, though they admit that those particles which go to make up gold or lead may be identical, only the number and arrangement of particles differing. Each atom is composed of one central particle, the proton, and one or more satellites, the electrons.

The conception is somewhat analogous to that of our solar system. Here the proton—the sun—is the nucleus around which a number of planets—electrons—rotate. A mysterious force, gravitation, pulls the planets toward the sun, while another, perhaps even more mysterious, is exerted in an opposite direction, thus holding them to their courses.

In the atom two contending forces are thought to exist, each exactly counteracting the other, and it is held that each electron holds a negative charge of electricity, while the proton carries a positive charge exactly equal to the sum of the charges on the electrons of that particular atom, whether the number of electrons be one or many.

To speak of a *negative charge* as an entity seems analogous to considering *cold* as something other than an absence of heat. Names are, however, of little significance. We might call gravitation X and the opposing force Z, and with equal logic designate the force of the proton X and that of the electron Z. The point is that when X and Z are equal, the planets and the electrons behave themselves, and that when something disturbs that equilibrium, not only the bodies most concerned, but perhaps all contiguous bodies, are affected.

The very nature of matter has been altered by disturbing the force-equilibrium of the atom. The atom of hydrogen unites with chlorine to form an acid, in which case an excess of positive electricity is exhibited; it unites with sodium to form a base, in which case the ions are said to be negatively charged.

Abandoning the theory of the ether, it seems apparent that that hypothetical medium "of extreme tenuity and elasticity," which pervades all bodies and perhaps all space, is the subtle force called "electricity."

That heat and electricity are related is denied by many physicists. Yet Willis H. Carrier, whose standing as a physicist and thermal engineer is recognized, conceives the probability of their identicalness. That the integral atomic forces apparently do not exhibit manifestations of heat is not conclusive evidence. Within the limits of their thermal capacities, water molecules in the form of vapor give no evidence of their contained heat, other than that pertaining to mutual attraction.

Selecting Alloy Pipe

An apparently unimportant feature may cause a radical difference in the behavior of pipe. As an example of this, a mill making parchment paper by running a special grade of paper through a bath of weak sulphuric acid was in need of some rolls which had to be submerged in the acid. An alloy was selected which was highly resistant to weak sulphuric acid, but the rolls rapidly failed. Investigation brought out the fact that certain copper pipes were immersed in the acid, thus producing copper sulphate in the solution, and this copper sulphate caused the action on the rolls. Another alloy, resistant both to copper sulphate and weak sulphuric acid, was selected and the rolls gave excellent service.

The man who is called upon for advice in the selection of a corrosion resistant alloy pipe should make sure that he knows all of the operating conditions. If he is not certain of his ground, it should be remembered that it is usually possible to determine the behavior of any alloy pipe by exposing a sample under service conditions.

INTERVIEWS OF INTEREST

Engineering Backgrounds

Engineering education has absorbed the working life of Dr. Mortimer E. Cooley, 1930 recipient of the Washington award, an honor paid jointly in recognition of "devoted, unselfish and pre-eminent service in advancing human progress" by the *American Society of Civil Engineers,* the *American Institute of Mining Engineers,* the *American Society of Mechanical Engineers,* the *American Institute of Electrical Engineers,* and the *Western Society of Engineers.*

Yet at no time during the period of Dr. Cooley's preoccupation with educational matters has such preoccupation interfered with his broad and progressive interest in the latest types of engineering development. The occasion of our recent interview with him afforded as comprehensive a discussion of things that are new as it has ever been our pleasure to enjoy.

"The engineer needs to be the most broadly educated person in the world," declares Dr. Cooley, with an enthusiasm that would leap all obstacles to having it so, "he needs not pragmatic sense merely, but cultural things. Probably more than any other professional man, the engineer needs to delve deeply into psychology and other special aids in human contact. For the good engineer is nearly always far in advance of his times and has to 'sell' himself and his progressive ideas against ignorance, and prejudice, and personal predilection or general apathy."

Dr. Cooley's discriminating intellect and sympathetic sense are in themselves the strongest argument in favor of ample academic opportunity for every engineer. His interest in the arts, his feeling for rhythm, his willingness to work hard for fine effects are what we covet for ourselves.

All of which lends interest to what he is about to formulate (in collaboration with Professor O. W. Boston of the school of engineering, University of Michigan) as chairman of the first engineering committee appointed to organize engineering exhibits for the Museum of Science and Industry in Chicago.

"The enterprise of the Museum of Science and Industry has not been undertaken a moment too soon," states Dr. Cooley. "Too many of us are prone to forget all that has gone before in the way of engineering invention. Engineering is not all in the future. It is quite as definitely of the past, a continuity, a developmental thing.

"Even now, precious early models of machines have been lost and it required a foundation to make it possible to reconstitute their origins and set them going in the interest of science and of industrial education. It is a tremendous opportunity—a life-time undertaking. We invent machines and glory in our prowess, but this is almost the first consistent effort to trace the social measure of our work. We are working now on high speed tools. The whole social history of mankind is bound up in such a study project."

As the first dean of architecture and engineering of the University of Michigan, Dr. Cooley organized the first course in heating and ventilating ever offered in the United States. That was before engineers had become such specialists that they had ceased to speak a common language.

At that time, according to Dr. Cooley, there were only two books available on heating and ventilating for texts in such a course. "They were good books, too," states Dr. Cooley, "books well worth reading now."

"A Practical Treatise on Heat," a British text by Thomas Box, published in 1863 by E. and F. N. Span, Dr. Cooley describes as an interesting example of sane, early backgrounds. "Old Thomas Box exhibits all of our boasted thoroughness of analytical method. He had no kata thermometer, but he took his temperature readings in the fundamental work on heating of buildings at many points within the room. More particularly, he considered readings just inside and just outside of external walls, and still another reading in the open.

"All these readings entered into his calculations. He also understood how much easier it is to heat larger spaces than it is to break such space up into small units and overcome the vagrant air currents that come up to the confusion of our most careful calculations.

"The American Society of Heating and Ventilating Engineers is studying heat loss and heat transmission at the Universities of Minnesota, Wisconsin and Illinois. Thomas Box covered every fundamental factor of the kind for his time. We do it over now merely to arrive at new constants for new materials that we employ and new types of construction. His work still stands.

"The other book we used was an American work by Baldwin. Box dealt with theory; Baldwin dealt with practice of heating. They served us well.

"What the engineer of today needs chiefly is to achieve an engineering perspective on broader problems of materials, markets, science. He needs to come out into the open and utilize his engineering thought in economic matters as well as in building construction and mechanical appliance. The world needs more precision for the world's work. The engineer needs deeper insight to think it through."

Positive Ventilation for Insurance Building

Childs and Smith, Chicago architects, in a building recently completed for the Hardware Mutual Insurance Company, Stevens Point, Wisconsin, have employed a system of positive ventilation which is almost new in middle western states. F. X. Thale, engineer on the project, states that the essential features of the method consist of blowing into the rooms at ceiling heights high velocity currents of untempered air. The pressures are such as to overcome the natural tendencies toward window infiltration, and the high point of introduction of the cool outside air counteracts the usual con-

dition of overheat at points close to the ceiling. There is also obtained a continuous slight oscillating air movement that provides diffusion.

Air discharge to the rooms is made through inlets at ceiling height that vary in dimension from 1 in. high by 8 in. long to 1 in. by 16 in., according to room space served. Grilles are painted to match the decorated walls, which makes them inconspicuous. Air discharge is through swivel nozzles capable of deflection in any desired direction. Louvres on outlets serve further to break up air currents laterally. The rate of inlet flow is 1,000 feet per minute and the fresh air supply is figured on a basis of four changes per hour.

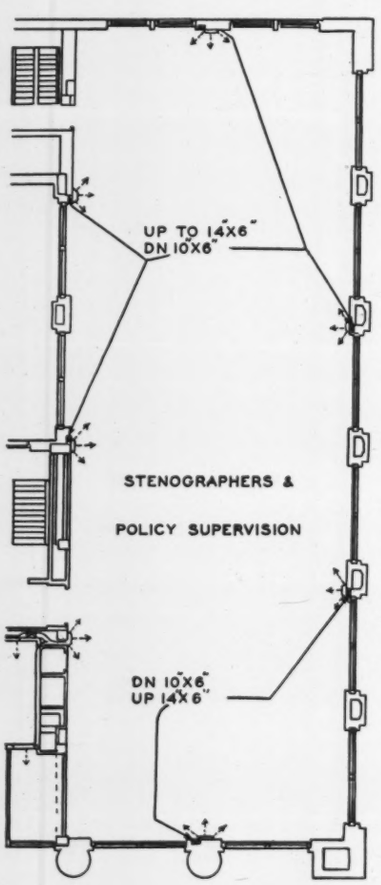
Mr. Thale states that this amount of air sustains a balanced relationship to normal filtration so that no excess of radiation is called for on account of the fresh air above the normal figure for heat leakage. The system handles about 15,000 cubic feet of air per minute.

The Stevens Point installation is the first project of the kind from Childs and Smith, but it is being repeated in a similar building under way by the same firm at Fort Wayne, Ind. The same distribution system, but with certain fundamental modifications in the treatment of air, is to be seen in the Carbide and Carbon Building, Chicago.

The new building for the Hardware Mutual Insurance Company at Stevens Point represents a 1,000,000 cubical content addition to an earlier unit containing 600,000 cubic feet. Structurally, the building is fireproof, concrete and steel construction, with outlines carried out in Indiana limestone.

Heating is with low pressure steam, vacuum circulation, with concealed panel radiation throughout. Wrought iron piping is employed for all steam and return mains. All mains follow a tunnel underneath the ground floor with head room for a man. Each piping system is painted a distinctive color so that maintenance and repair men can tell at a glance which pipes are steam supply, return mains, or gas.

Fan location is in a penthouse on the roof. Main fresh air ducts are housed in false ceiling space above the top story. Distribution of air to the several rooms is by independent vertical ducts along the outside walls. All duct courses are recessed and are flush with the walls.



VENTILATING AN INSURANCE BUILDING

A distinctive feature of this building is its floor plan, which takes full account of expert management factors in insurance work. A tier of large working rooms at the south wing of the building has office space 40 feet in width by 120 feet in length without an intercepting pier. Insurance management consultants on this job hold that this 40-ft. width is best for light, for supervision, and for speed. The illustration shows the second floor space of this type and indicates the air inlet openings and the manner in which they have been staggered so that no two inlets make direct cross-currents or create unnecessary turbulence because of intercepted flow.

In his preliminary studies for the new building, Mr. Thale has made certain interesting observations on the earlier unit with its full equipment for circulation of conditioned air. The operation troubles experienced in the older building were due to overheat, he says, and they were met by a set of maintenance rules of great general value.

The attention of the Hardware Mutual Insurance Company to air environment has been on strict economical grounds. The concern found that it could count upon better output and more dependable work with less fatigue on the part of working groups when office quarters were maintained at moderate temperatures. Overheating was brought under control by operation changes which sent the fan-propelled air through at much lower temperatures than has been the usual practice.

It was not a very radical transition, therefore, to supply their new quarters with wholly untempered air. The new system is capable of deflecting the air in any desired direction within a room. Outlet dampers are set and not manipulated either independently or collectively after speed, quantity, and direction factors have been determined by repeated tests. Thermostatic regulation obtains as in other systems, and operation is constant.

Photoelectric Cell Used in Research

The use of the photoelectric cell has introduced a nicety of observation, a precision of record, and a simplification of experimental method and personnel that account for the prominence the device has commanded in recent scientific discussions. F. G. Brickwedde, chief of the low temperature laboratory, United States Bureau of Standards, describes for us photoelectric cell thermoregulators of the type utilized in his work with R. B. Scott. Its advantages in many types of thermo-regulation in other fields is quite apparent.

Photoelectric cells are used in industry to determine the opacity of flue gases, to count and sort packages, etc., and to control oil burners.

Fig. 1 is a diagram of a photoelectric cell thermoregulator which makes use of thermal electromotive force as the thermosensitive property for the purpose of maintaining X at the same temperature as Y.

This is the type of regulation needed to keep the shield of an adiabatic calorimeter at the same temperature as the container, and to keep the guard ring of a thermal conductivity apparatus at the same temperature as the plate.

The ends of the thermocouple are connected to a mov-

ing mirror galvanometer G which forms an image of a lamp filament L on a screen K placed in front of the photoelectric cell C.

The positions of the lamp, screen, and photoelectric cell are so adjusted with respect to the galvanometer that when X is at the same temperature as Y and no current

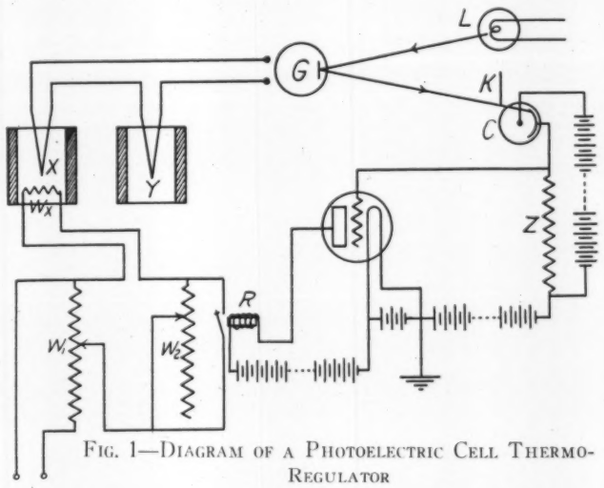


FIG. 1—DIAGRAM OF A PHOTOELECTRIC CELL THERMO-REGULATOR

flows through the galvanometer, the image of the lamp filament is focused on the edge of the screen K.

When the temperature of X changes from that of Y, the image moves across the edge on to the screen or photoelectric cell, depending upon the direction of the temperature change. The change in the illumination on the photoelectric cell varies the photoelectric current through the cell.

The photoelectric current and its changes are too small to operate a relay. They are therefore amplified, using the usual method of radio tube amplification, by a radio tube amplifier in the plate circuit of which is connected the relay R.

The photoelectric current is made to vary the potential of the grid by connecting the grid between the photoelectric cell and a high resistance Z, of the order of 40 megohms, connected in the photoelectric cell circuit. The change in the potential of the grid is equal to the change in the potential drop across Z. The relay R opens and closes a shunt circuit across a resistance W_2 connected in series with the heater W_x in X. The steady heating current is varied by W_1 and the thermostating current by W_2.

Since it is the usual practice in regulating low temperatures to set the refrigeration in excess of that needed, and to compensate for the excess with electrical heating, the regulator described can be used for controlling both low and elevated temperatures.

By placing the reference junction Y of the thermocouple in an ice slush bath, and connecting the thermocouple and galvanometer to a potentiometer, the enclosure X can be maintained at any desired temperature by balancing the potentiometer in the same way as would be done in making a determination of the temperature of X with the thermocouple.

Other thermosensitive properties besides thermal electromotive force can be used to perceive the temperature changes. The temperature variation of electrical resistance can be used by placing in X a resistance which is made one arm of a Wheatstone bridge to which the galvanometer is connected. The bridge is balanced as would be done in determining the temperature of X with a resistance thermometer.

A radiometric thermopile or vacuum thermocouple connected to a galvanometer can be used to control high temperatures by focusing the radiation from a small opening in the furnace on one set of junctions and balancing the deflection of the galvanometer with the radiation from an auxiliary lamp focused on the reference set of junctions. Changes in the temperature of the furnaces are accompanied by changes in the intensity of the radiation from the furnace which, as before, is made to produce a deflection of the galvanometer mirror. By attaching a mirror to the moving arm of a bimetallic strip it can be used as the thermosensitive element of an automatic thermoregulator. Although the use of the bimetallic strip does not permit as close regulation as can be obtained using thermocouples and electrical resistances, it does have the advantage that it does not require the use of a galvanometer and is simpler in its operation.

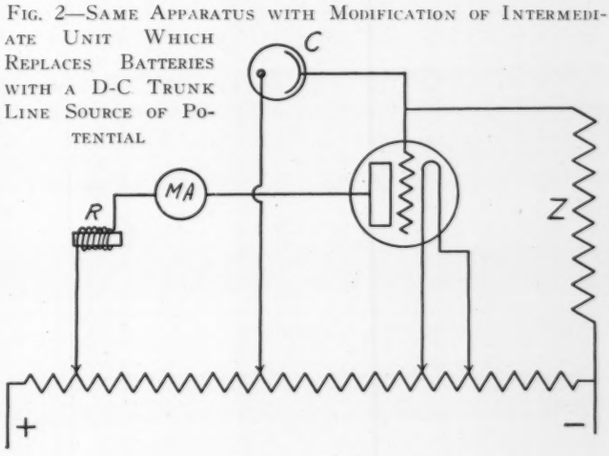
The photoelectric cell can be made to control automatically any operation and regulate its result if it has some property that can be used through its changes to vary the intensity or the direction of propagation of a beam of light. The photo-electric cell and radio tube amplified circuit can be used as shown in Fig. 1.

Fig. 2 represents a modification of the intermediate unit of a photoelectric cell regulator which replaces batteries with a d-c trunk line source of potential. This makes the regulator less expensive and obviates the inconveniences of run-down batteries.

A resistance is connected across the trunk lines and the proper potentials tapped off as shown in the figure. The sensitive plate of the photoelectric cell C is connected through the high resistance Z to the negative end of the rheostat, and, as before, the grid is connected between the cell and resistance Z. The negative side of the filament of the amplifier is connected at a place where the difference of potential between it and the negative end of the rheostat is of the proper magnitude for the negative grid bias.

The potential difference across the ends of the filament is adjusted to that recommended for use with the tube. The anode of the photoelectric cell and the plate of the amplifier are connected to the rheostat so that the applied potentials are again those recommended for use with the cell and tube. An ordinary slide wire rheo-

FIG. 2—SAME APPARATUS WITH MODIFICATION OF INTERMEDIATE UNIT WHICH REPLACES BATTERIES WITH A D-C TRUNK LINE SOURCE OF POTENTIAL



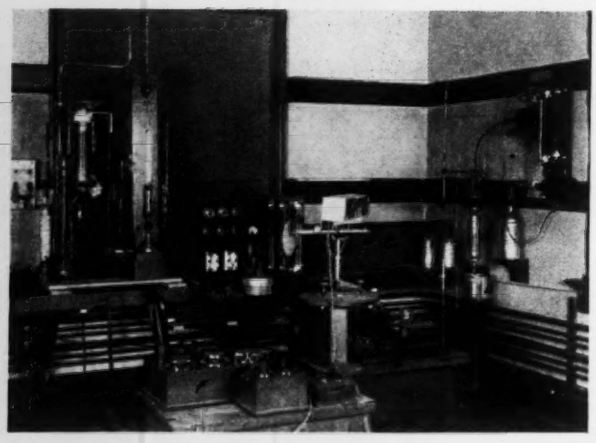


FIG. 3—APPARATUS FOR CALIBRATION OF THERMOMETERS USING PHOTOELECTRIC CELL

stat can be adapted for the tapping off of the voltages applied to the cell and tube by using additional sliders, electrically insulated, from the guide rod on which they slide. The leads are connected to the contact arms.

So far, the photoelectric cell has found many industrial applications, and it has been fully appreciated in connection with problems of automatic control in laboratory work. Its application to practical matters pertaining to heat control has only begun.

Fig. 3 is a photograph of the apparatus to which the photoelectric cell thermoregulator has been applied, for the calibration of thermometers and thermocouples at low temperatures. The bath for maintaining the low temperature is contained in the double walled vessel *A* to which the refrigeration is supplied by surrounding this vessel with liquid air contained in the large Dewar flask *B*. The bath is circulated by a motor-driven propeller and its temperature is maintained constant automaticaly by a *photoelectric cell thermoregulator*.

The thermoregulator galvanometer, photoelectric cell, and amplifier tube are mounted in the box *C*, and the units which require adjustment are mounted on the control panel *D*. The thermometers and thermocouples to be calibrated are immersed in the bath together with a standard platinum resistance thermometer with which they are compared. The resistance of the platinum thermometer is determined by means of a Wheatstone bridge *E*, and the electromotive force of the thermocouple under test is measured by the potentiometer *F*. A single operator has access to the measuring instruments and controls without leaving his position before the galvanometer telescope.

A more complete description of this apparatus is being prepared for publication in the Bureau of Standards *Journal of Research* under the title, "A Precision Cryostat with Automatic Temperature Regulation."—*S. P. M.*

Difficulties in sampling from an air stream in a pipe arise from the varying velocity and the varying fineness and density of coal over the cross-section of the pipe. The varying velocity of the stream at different points causes not only a variation in the quantity of coal in suspension, but also a variation in the fineness of the particles at different points.

Materials for Drying by Adsorption

IN the application of lower humidities to hospitals and to the electrical industry the choice must be made between cooling by refrigeration and drying by adsorption where air conditioning equipment is purchased. At very low humidities, the latter method has some special advantages which deserve consideration.

The method used in adsorption consists in passing the air through some material which has the peculiar property of picking up and retaining moisture on its surfaces. When such materials become saturated with moisture, heat is applied to drive the moisture off. This operation is termed "activation." The material is then ready for another run. It is therefore necessary to have at least two chambers or cells of adsorbing material connected to the air conditioning system in order that one cell may always be in service.

Various gels have been used to a considerable extent for this purpose; silica gel is one of the most popular. They consist of crystal-like materials with a granular structure, a rather indefinite color and glistening surfaces. Silica gel will remove 1.7 grains of moisture per minute per pound of gel for a period of eight hours. After such period the gel must be activated for four hours at a temperature of about 425 F.

Other materials which may be used for adsorbants of moisture are fuller's earth, charcoal, ferric hydroxide, aluminum hydroxide and silica from hydrogel. Next to gels, charcoal is the best known adsorbant.

An efficient charcoal adsorbant is cocoanut charcoal. When prepared for use it is activated by steam, treated with acid to remove mineral matter and then washed free of acid. It is used in sizes of from 12 to 20 mesh and is activated at a temperature of 1020 F. Other charcoals are plumstone, birch, German impregnated, activated coal and common wood. Suitability for adsorption purposes requires that the charcoal have a fine porosity, but that it be neither soft nor too brittle. These latter qualities cause charcoal to break down into a fine dust.

The adsorption capacity of charcoal is utilized in many laboratories for securing a high vacuum. At 0.4 inches absolute pressure birchwood charcoal will adsorb 194 grains of water per pound of charcoal. At 0.92 inches absolute it will adsorb 5,490 grains per pound of charcoal. As there are 7,000 grains in a pound, it is evident that charcoal is very efficient as an adsorbant. At atmospheric pressure and an equivalent air temperature (77 F), silica gel will adsorb 816 grains of water per pound of gel.

While the information furnished does not by any means cover the field of the materials usable for adsorption of water from air, it at least is helpful to those who are interested in securing low humidities or a low vacuum.—*M. T.*

Blow-Off Valves for Ammonia Piping

If you have to put in a blow-off or charging valve, be careful never to have one point upwards, because a man opening the valve may get a squirt of ammonia in his face and injure his eyes. A pipe fitter does not always think of those things, but they are very important.

PRACTICAL PIPING PROBLEMS

Emergency Water Connection for Boilers
Repairing a Sprinkler System
Blowing Out Hydraulic Lines

by
W. H. WILSON

Cross Connections for Sprinkler System

Cross connections in pipe work are useful and necessary in many installations, where they are used for convenience and in cases of an emergency. There are times when these cross connections can be as troublesome as they are beneficial.

Fig. 1 shows a connection for charging a dry pipe, fire protection, sprinkler system with compressed air pressure. The sprinkler system was equipped with a standard type, automatic sprinkler alarm valve, which required air pressure in the piping to balance the water pressure under the water valve disc and keep it in the closed position at normal times. The opening of a sprinkler head from the heat of a fire or other causes or the loss of the air pressure in the piping system from any cause would relieve the pressure on the valve disc and cause the valve to trip (open), which would automatically send in an alarm to the fire department headquarters.

This particular sprinkler valve had been in use for a number of years when it began to trip prematurely. An inspection failed to locate anything wrong and it was re-charged each time and seemed to be in good condition. It was then discovered that the valve would trip on a Sunday night and when re-charged would remain

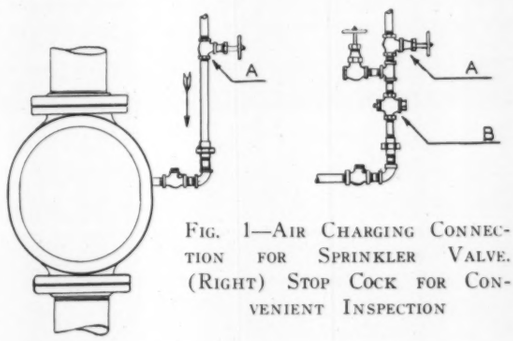


FIG. 1—AIR CHARGING CONNECTION FOR SPRINKLER VALVE. (RIGHT) STOP COCK FOR CONVENIENT INSPECTION

charged until the same time the following week. The air pressure for charging was supplied from the compressed air lines supplying the plant equipment. A check up on the plant operating conditions showed that air pressure was maintained on the shop pipe lines continuously until midnight on a Saturday. The air compressors were then shut down until they were started up at 1:00 a. m. Monday. Air pressure was then maintained continuously until the end of the week.

The air charging valve was examined and found to be leaking through. The automatic sprinkler valve was not equipped with a small relief valve to insure a reduced air pressure on the sprinkler system and the sprinkler maintenance employes were not particular as to what air pressure was maintained on the sprinkler system as long as there was enough to hold the valve disc in the closed position. When the air pressure in the shop pipe lines went down, the air pressure in the sprinkler system leaked back through the charging valve into the shop lines, reducing the air pressure in the sprinkler system and causing the automatic sprinkler valve to trip and send in an alarm. Air charging connections of this kind are equipped with a check valve to guard against a back flow of air, but in this case the check valve seat was in bad condition and leaking as bad as the charging valve.

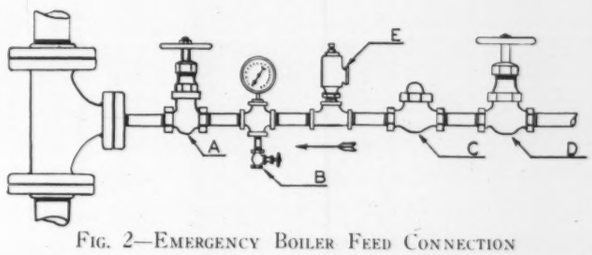


FIG. 2—EMERGENCY BOILER FEED CONNECTION

This condition was remedied by reseating the charging valve, *A;* to provide for a convenient way of inspection in order to avoid future troubles of this kind a stop cock, shown at *B,* Fig. 1, was placed in the air supply. This was in addition to the charging valve with a tee in between the two shut-offs, the side opening of the tee being equipped with a valve that could be opened to the atmosphere to show if there was any leakage that would cause a repetition of the former trouble.

Emergency Water Connection When Boiler Feed Pumps Fail

Fig. 2 shows an emergency water connection from a hydraulic line which can be used when the boiler feed water pumps fail to supply water to the boilers.

This type of a connection would be suitable for a steam boiler plant that also has hydraulic power near the boiler room.

Hydraulic systems usually carry a water pressure several times greater than the pressure on the boiler feed water lines. In order to prevent the hydraulic pressure accumulating in the feed water pipe lines, it is safer to use two valves on this cross connection with a suitable relief valve in between these valves.

A is a gate valve suitable for the highest hydraulic pressure that may be liable to get to this valve. *D* is a hydraulic globe valve and *C* a check valve of the same requirements. A globe valve is used to permit more convenient regulation of the water supply when this connection is in use. A suitable relief valve, *E,* is placed in between these two valves and set for the pressure required on the boiler feed water lines; *B* is a drip valve. A pressure gage installed as shown will be a help to the operator in regulating the water supply.

The check valve is an added precaution in case the hydraulic system is not in use and the valves should be accidentally opened. Water from the feed line would then get in the hydraulic lines.

The pipe and fittings for this pipe connection should be of the same quality and strength as required for the valves.

When this connection is not required for furnishing water, valves *A* and *D* are kept closed and the drip valve *B* is left open, which will show whether or not the valves are tight and free from leakage.

Blowing Out Hydraulic Pipe Lines

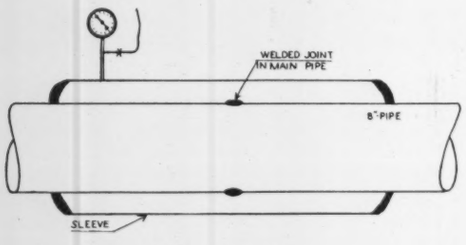
A connection similar to this may be used for blowing out hydraulic pipe lines when shutting down the hydraulic equipment, to prevent damage in freezing weather. In this case the check valve is essential, as failure to close valve *D* (which would be the air supply valve, in this case) would mean the possibility of water from the hydraulic system getting back into the compressed air pipe lines.

The practice of using two shut-off valves (with a drip valve in between) on cross connections between different pipe lines is a safe and convenient way of being assured that there is no leakage or flow between these different pipe lines, when it is not required.

Testing Pipe Joints

A novel pipe joint was used on an 8-in. welded pipe line crossing the Hudson River, Beacon to Newburgh. It was made by welding the 8-in. pipe together and then slipping a piece of 9-in. standard pipe as a sleeve over the pipe at the joints, and welding through the sleeve.

This pipe line was welded together on a scow and then lowered into the river. The extra welding of the pipe sleeve reinforces the joint, but it was used principally for testing the welded joint in the pipe line.



Sectional View

The testing of a large and long pipe line as it is being welded, especially when it is to be lowered in a river, often means trouble, delays and expense to pump up the pressure on the line at frequent intervals. By using the method described here, the welding of the pipe joint and the sleeve was finished, a small tapping was made in the pipe sleeve and a pressure of 350 lb. admitted to the annular space between the sleeve and the main pipe line. A gage was attached to this connection and the pressure shut off, allowing the gage to show the pressure within the sleeve. If this pressure held on the gage, it would show that the welded joint on the 8-in. pipe line, as well as the welded joints on the sleeve, were tight, the joint on the 8-in. pipe line being tested from its outside pipe surface.

The content of the annular space between the pipe line and the sleeve was very small, something like 1/10 of a cubic foot, requiring very little of the nitrogen that was used for this purpose, it being supplied in the regular commercial steel containers. Nitrogen, being an inert gas, was safe to use for the testing.

We are indebted to the May issue of the Welding Engineer for this information.

Brine Piping and its Installation

Brine pipe in general is of larger size than that for ammonia or carbonic acid. It also operates under lower working pressures. Usually, standard weight piping is sufficient for all ordinary pressures.

The same rules for threads apply as in any first-class threaded pipe work.

Threads

Threads should not be shouldered and should be entered three or four by hand. A 5 in. pipe ought to enter the fitting about ¾ in. or ⅞ in. and have two or three threads sticking out to make sure it is not shouldered.

Red Lead as Lubricant

Red lead is a very good heavy lubricant to be used when screwing the pipes together and it helps a little to seal discrepancies. White lead will seal the joint a little better, but it sticks so hard that it is very hard to take the pipe apart and pipe fitters do not use it so much for that reason. Some people mix a little asphalt with the red lead, which helps make a joint in case of imperfections in the threads.

Rusting Up

Calcium brine will not rust up a joint, but if it starts to leak it will continue and if taken apart it will be apt to leak again. Hence, when piping is installed and tested, if there are any slight leaks which drip but do not run continuously they will rust up in the course of two or three days and be tight and give no trouble. If the brine is put in immediately it will start to leak and will never rust up and will cause trouble. Generally, there is plenty of time to let the water from testing stay in for two or three days, putting the pressure on again at the end of that time to make sure it is tight before the brine is put in.

If the pipe is exposed to cold weather, it should be drained out so it does not freeze. Generally, good steam piping will fill all the requirements for brine piping.

Air Chambers

In case of change of direction of flow of brine, or if for any reason an air chamber is needed, it should lead off from the end of the pipe which takes the thrust as the direction of flow of the brine is changed. An air chamber on top of the pipe does not do any good, but must lead off from the end of an elbow. Piping must be strongly braced to take care of end thrusts.—*Henry Torrance.*

Ventilating Rooms for Light Treatment

RECENT discussion among physicians as to the respective merits of outdoor and artificial light cures in tuberculosis has led to the assertion that part of the benefit derived from heliotherapy is due to the movement of cooling air currents, the air as well as light speeding up life's processes and building up bodily resistance to disease. Accordingly, the demand for proper ventilation in rooms in which Alpine light treatments are given is of increasing importance.

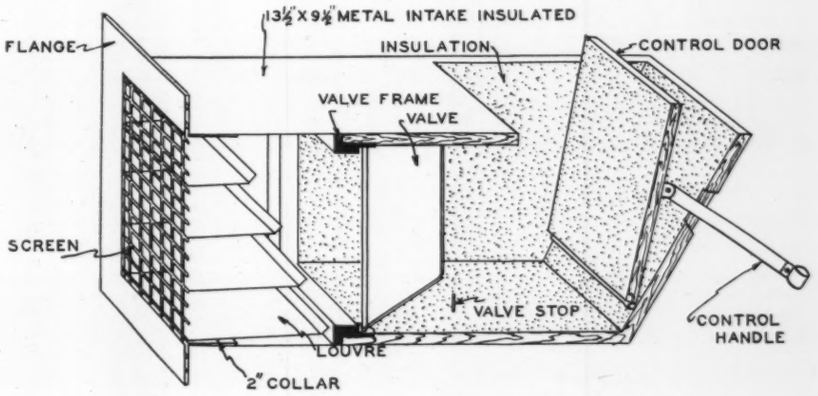


FIG. 1—A VENTILATION ARRANGEMENT MADE EFFECTIVE IN TWO SMALL ROOMS FOR ALPINE LIGHT TREATMENT AT CHILDREN'S PREVENTORIUM, ST. PAUL. SECTION THROUGH CENTER OF INTAKE. FLANGE, 2-IN. COLLAR AND LOUVRES ALL IN ONE PIECE, BUT SEPARATE FROM INTAKE

Many elaborate and highly efficient systems have been devised for this purpose. The St. Paul project described shows the way for a simple solution. When the Children's Preventorium, at St. Paul, Minn., was erected, artificial ventilation was not included for the two Alpine lamp rooms. But the superintendent felt that it should be and it was decided to install the apparatus shown. The requirements laid down were that it should introduce a sufficient circulation of fresh air dilution into the rooms while the lamps were being used, that the air would be approximately pure, and free from odors. There could be no draft on the floor as the children lay on it on pallets; and the room temperature must not be lowered in cold weather below a comfortable point.

In installing the ventilation system, ducts of proper size were used to draw air from the floor line vertically up to the roof. A fan at the roof line draws the air up through the ventilator.

A simple but effective air intake was introduced into each of the rooms high up in the wall next to the ceiling. The intake consists of a box-like arrangement, containing a screen, collar, and louvres in the outer wall. The air then passes by an automatic valve intake which permits the air to enter freely, but which acts like a check valve in a water pipe and will not let the air back-draft out through it in the wrong direction. After the air passes the valve it is still in the air intake, but, as it is open at the top, the air is directed upward against the ceiling, is thrown across the top of the room and becomes warm without any possibility of causing a draft. In the opening at the ceiling there is a control door that permits of proper regulation, depending upon wind pressure or the pressure caused by temperature difference.—*S. P. M.*

Cow Barn Ventilation

A GROUP of engineers returning from the annual convention of the *American Society of Heating and Ventilating Engineers* held in Philadelphia last January were lounging in the smoking compartment of a sleeping car and one of the group remarked that the activities of the heating and ventilating engineer now covered so wide a field that work was being carried on in our own profession that many knew nothing about. John Howatt, chief operating engineer, board of education, Chicago, one of the group, confirmed that statement and added that he had just learned from one of the members from Wisconsin of some of the research work being done for farmers and stock and poultry breeders. What with thermo-couples, recording clocks and indicating devices, the unfortunate hen at one of these experimental stations could not determine whether she was poultry or a specimen.

Everyone raised on a farm remembers how much warmer it was inside of the cow barn than it was inside of the horse barn on a cold night, but when you were on the farm you took the fact for granted and did not try to arrive at any explanation. The heating and ventilating engineer, however, engaged in studying air conditioning of farm buildings has learned that a cow gives off nearly 6 Btu per hour per pound of flesh, whereas a horse gives off only about 2 Btu per hour per pound of flesh. This accounts for the warmer cow barns. The high body temperature of a cow, about 101 deg., the enormous amount of discharge to the gutter, the great volumes of air exhaled per hour and the excessive moisture on the skin all account for a great rate of heat dissipation. The heat balance is maintained by the oxidation of large quantities of food eaten.

Navy Department Instructions for Ventilation Tests

In the March issue of HEATING, PIPING AND AIR CONDITIONING attention was invited to the recent publication of Appendix 8 of the General Specifications of the Bureau of Construction and Repair of the Navy Department "Specifications for Testing Ventilation Systems on Vessels of the United States Navy." This publication, a revision of earlier instructions on the subject, covers clearly and briefly the acceptable methods of making delivery tests of ventilation systems on naval